GOVERNMENT AND SCIENCE

REVIEW OF THE NATIONAL SCIENCE FOUNDATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS

U.S. HOUSE OF REPRESENTATIVES

EIGHTY-NINTH CONGRESS

FIRST SESSION

VOLUME I

JUNE 23, 24, 25, 29, 30; JULY 1, 6, 7, 8, 13, 14, 15, 20, 21, 22, 27, 28, 29; AUGUST 3, 4, 5, AND 19, 1965

[No. 6]

Printed for the use of the Committee on Science and Astronautics

U.S. GOVERNMENT PRINTING OFFICE

51-204 WASHINGTON : 1965

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CONTENTS

VOLUME I

TESTIMONY OF

BIOGRAPHIES

NATIONAL SCIENCE FOUNDATION

WEDNESDAY, JUNE 23, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., the Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

We begin our hearings today with Dr. Leland J. Haworth as our first witness. Will you come forward, please, Dr. Haworth.

I am particularly pleased not only to have Dr. Haworth as our first witness at these hearings, but I am also happy that the chairman of the full committee, Mr. George P. Miller, is here with us. I would appreciate it, Mr. Chairman, if you would make the opening remarks.

Thank you, Mr. Daddario.

Mr. MILLER. I am very happy to be here and to welcome Dr. Haworth and his staff. Ever since this committee was formed we have been aware of our specific responsibilities toward the National Science Foundation and our legislative duty to oversee the Foundation's activities and programs.

For two reasons, however, we have not up to this point undertaken more than an annual briefing session with Foundation officials.

One reason was that the national space program—also our specific responsibility—was just getting underway and needed an inordinate amount of attention. Both the stakes and the costs were very high, so that we on the committee had no choice except to devote our time almost exclusively to the space endeavor.

The second reason was that the Foundation itself was in the midst of a transition, with a change of leadership and other personnel—and it appeared best not to begin a general review of the Foundation until the incoming group had a chance to get its bearings and become oriented to the problems facing it.

Nonetheless, almost 3 years ago Mr. Daddario and I began discussing the advisability of a complete and thorough review of the Foundation's mission—one that would be critical but constructive. At that time I indicated I would like him to chair a subcommittee to undertake the task just as soon as the proper moment arrived. Mr. Daddario concurred and, I know, has long had these hearings scheduled on the agenda of this subcommittee.

The appropriate moment is now here.

It is my hope and belief that these hearings will prove helpful and beneficial to the Foundation and, through it, to the American and International Scientific Community. The Foundation is a most important balance wheel in our national scientific and technological effort. It should have the benefit of our understanding and whatever assistance the Congress can give.

I want to congratulate you on getting these hearings underway. I am sure that they will be fruitful.

Thank you.

Mr. DADDARIO. Thank you, Mr. Chairman.

At the outset of these hearings I should like to pay special tribute to the leadership of Chairman Miller in inaugurating these hearings and supporting their preparation. We are particularly indebted to him for providing sufficient time, staff help, and consultation to do the job which is to be done.

We also are grateful for his perception and patience.

Underlying this review is the realization that many things have changed in the past 15 years. The concepts of the Foundation and the mission given to it by Congress in 1950 have proved their validity. They desire, however, reexamination at this point in time.

It is the job of the committee to do this and, if changes appear warranted, to bring about new legislation which will effect the necessary revisions.

In this effort we hope to have the help of those most cognizant of the Foundation's activities and goals, both in Government and out. Hence we have arranged to hear some 40 witnesses, beginning today with the Foundation's distinguished director, Dr. Leland J. Haworth.

As we proceed with the hearings, we would do well to keep in mind how rapidly the National Science Foundation has grown. To me, this suggests the scope of the Nation's need for the Foundation's services. In 15 years the National Science Foundation budget has increased from about a quarter of a million dollars to half a billion dollars.

It would be hard, indeed, for an agency to sustain growth at this rate without experiencing some problems.

So we hope to establish some helpful evidence in at least three major categories.

(1) How well has the National Science Foundation performed the tasks which Congress set out for it in the basic act of 1950?

(2) What roles, responsibilities, and missions should the National Science Foundation assume in the future?

(3) What tools will the Foundation need in the years ahead to accomplish its work?

Just a few weeks ago the full committee met with a special panel of the National Academy of Sciences to receive a comprehensive report of the Nation's needs in basic research. Those of you who have read the report will recall the forecast of an expanded rôle for the National Science Foundation. You may also have noticed some observations concerning the shifting status and operations of other Federal agencies engaged in scientific and technological research.

I point this out in order to emphasize that during the period of the Foundation's lifetime, there have likewise been many changes in the dozen or so Federal departments or agencies active in the scientific

field. We will, therefore, be obliged to consider the relationship between these entities and the Foundation as well as focusing on the Foundation itself.

All in all, the task before us is broad and will require a good deal of time and concentration. This is a major challenge which the subcommittee faces.

I have already indicated my pleasure, Dr. Haworth, in your being with us today. We recognize the great effort that you have put into your work as Director of the National Science Foundation, and we are looking forward to your participation with us for the next few days.

Mr. Roush. May I echo what you have said, and also point out that Dr. Haworth has received at least three degrees from Indiana University, and is a product of the great midwestern section of this country. I am happy to see him honored in his present position as Director of the National Science Foundation.

Mr. Daddario. Thank you, Mr. Roush.

STATEMENT OF DR. LELAND J. HAWORTH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. Haworth. Thank you Mr. Chairman and members of the committee.

I certainly appreciate this opportunity to appear before you and to try to tell us something about our current thinking, our programs, our plans, and so forth.

With your permission, Mr. Chairman, I would like to proceed along the following lines. I have a document which lies before you of about 20 pages. At the rate I read it would probably take 25 or 27 minutes to read. This document very, very briefly tells a history of the Foundation and the kind of programs it has in qualitative terms. It is not statistical, but I hope it will give a basic foundation for the discussions from that point on.

Having read this document, I would like to proceed to extemporaneous discussion using a set of charts, of which there are a good many. This will be a fairly lengthy process I am afraid.

Then, finally, I would like to end with a prepared statement, which is not yet finished, that will lay before you some of the things we forsee in the future, some of the problems we face, some of the possible changes in direction or perhaps changes in emphasis that we might make.

If that is satisfactory, I will proceed along those lines.

Mr. Daddario. That is most satisfactory, Dr. Haworth.

Dr. Haworth. Then, I will proceed, Mr. Chairman, to read the document that lies before you.

The past 15 years, which cover the span of the Foundation's existence, have been important years for science. They have been years marked by rapid advances in research and science education. It seems to me these hearings on the Foundation are most timely. The members of my staff and I stand ready to discuss our activities, to provide data, and to cooperate in whatever ways the committee sees fit in order to insure that these hearings are both productive and constructive.

Two recent reports stimulated by this committee provide background on the programs and many of the problems which have con-

cerned the Foundation during its history . The first, prepared by the National Academy of Sciences and entitled "Basic Research and National Goals," is directed at an understanding of the needs for and of an expanding science. The second, prepared by the Science Policy Division of the Legislative Reference Service of the Library of Congress, and entitled "The National Science Foundation—A General Review of Its First 15 Years," provides considerable detail on certain aspects of NSF's history and programs.

Mr. DADDARIO. I would like to add just one point here. In referring to these reports, I would like to call attention to the fact that you also have prepared for us a study on science education in schools in the United States. This covers both the elementary and secondary schools, and there is a followup report on graduate schools and colleges. I think these are also significant contributions to the point you are raising here.

Dr. HAWORTH. Thank you, Mr. Chairman.

The issues raised in these reports on the character of the Foundation's, and, more generally, the Government's participation in research are fundamental. They are related to a group of problems which I identified and discussed as having particular significance in the last annual report of the Foundation.

These reports record the growth of the Government's interest in science since World War II. I need merely to review a few salient statistics to indicate the extent of that growing interest. In fiscal year 1950, when the Foundation was created, the Federal agencies obligated approximately $1 billion for research and development, of which about $50 million was for basic research. In 1960, the total obligations for research and development were $7.5 billion, of which $600 million was the portion for basic research. Currently, in fiscal year 1965, the amounts are estimated at $15 and $1.9 billion, respectively.

These statistics would have little meaning if they could not be related to an increased tempo in science and to a qualitative improvement in the resulting output of the scientific effort. This relationship is not difficult to establish. One has but to recognize the postwar position of American research and to consider the recent achievements of our Nation's laboratories. All of the Federal agencies which conduct or support scientific activities have contributed to this upsurge.

The Federal Government—in this case the totality of all Federal science-supporting agencies—provides funds for science and technology in pursuit of three objectives, which I described as follows in the Foundation's annual report:

A first objective is to make sure that our capabilities in the areas of science and technology are the very best the social structure can produce. This means that leadership must see to it that we have a vigorous and healthy scientific and technological base which will lead to continued social and economic advance. Scientific and technological progress must be viewed as dependent, in the long run, on two factors:

1. The need to maintain and constantly augment a fund of scientific knowledge derived through research, particularly basic research.

2. The need to strengthen science education, especially higher education, to be sure that we produce adequate numbers of young scientists and engineers qualified to do the things our national goals require.

A second Government objective is to develop, or have developed, the hardware, materials, and processes required for national programs conducted by the Government itself, such as those in military defense and space.

A third Federal objective is to foster and encourage developments that will react to the direct benefit of the people. Here, the distinction lies in the fact that the public rather than the Government is the "customer." Improvements in public health; better practices in agriculture; improved transportation; development of energy, water, and other resources; and conservation: these and many other applications of the sciences are properly the concern of the Federal Government since private elements of our society cannot be expected to assume sole or even primary responsibility.

All agencies contribute in some respect to each of these objectives. The National Science Foundation is primarily associated with the first, where as the other Federal agencies are primarily concerned with one or both of the others. Thus the National Science Foundation's mission is general and may be described as "the advancement of science in the national interest." In its pursuit the Foundation endeavors to promote the national scientific and technologic capability by supporting the extension of scientific knowledge and the strengthening of the educational processes leading to such extension.

The role of the Foundation can be better understood if we identify its sphere of responsibility within the complex of activities that are popularly known as research and development. These activities cover a very broad range; they are usually divided into three categories: basic research, applied research, and development. The boundaries between them are not sharply defined, nor can they be neatly compartmented.

Basic research seeks an understanding of the laws of nature without regard for specific utilitarian value. The real objective of basic research is not merely to discover a collection of separate facts by weighing this and measuring that, but to develop an understanding of nature by seeking out the why and how of nature's behavior. Basic research is important in several senses: it has very great intellectual and cultural value, it is the foundation upon which rests all of our technological advances, it is intimately involved in the education and training of first-class scientists and engineers.

Applied research is carried out with practical and, usually, but not necessarily, specific objectives in mind. Such research may involve special measurements to yield data needed for some engineering purpose. It could be a broad study of high-temperature materials for application to many purposes. Much applied research seeks detailed information regarding a specific situation for which the general laws are known from basic research.

Development is the systematic use of knowledge directed toward the design and production of useful prototypes, materials, devices, systems, methods, or processes. This includes the construction and testing of "hardware," including military weapons systems, space vehicles, nuclear reactors, and many other items great and small. This is the costliest aspect of the research and development spectrum, both in Government and in private industry. It is distinct and separate from research in that it applies the results of research to the production of end products.

All three areas of activity are important. Applied research builds on the results of basic research. Development builds on both. The more complete our underlying knowledge, the easier the task of applied research and of development. In the broad sense, research is in this era the foundation upon which rests all technological develop-

ment; such development is harvested from knowledge resulting from a great many experiments and the understanding derived from them. It would be a misconception of these activities if one sought to divide a 1-to-1 causal relationship between a specific development and a specific piece of basic research.

The Foundation's principal sphere of responsibility within the research and development domain is basic research and science education. These are closely related. Basic research is the extension of knowledge, and science education—particularly at the higher levels—is a closely related element clearly essential to progress in science. Not only does the search for knowledge on the frontiers of science provide experience and cultivate the student's ingenuity and resourcefulness, but it also becomes a part of the teacher-student-disciple relationship which lends vigor to our cultural development.

The special character of NSF was given to it in its enabling act of 1950. Under this broad mandate fall responsibilities for the promotion of basic research and education in the sciences, and for the pursuit of national science policy. By that statute and later legislative action, the National Science Foundation is defined to be the National Science Board and the Director of the Foundation. The Director is a full [voting] member of the Board, is Chairman of its Executive Committee, and serves as the Foundation's chief executive officer.

The Board has broad responsibilities for providing policy guidance for the Foundation and for approving its actions. Over the years, the Board has provided NSF with leadership and has served science and the Nation well. Although the Board continues to review new programs and problems relating to grantmaking activities, it has in recent years given primary attention to major policy problems and national issues relating to science. The Board has delegated to the Director responsibility for making final decisions on those operations for which there exist well-defined models and rules, except for those relatively few cases where very substantial sums of money are involved.

The range of current Foundation programs is quite varied. Perhaps you will permit me to describe some of these after making a few remarks to provide historical perspective. As you all know, the Foundation was proposed in 1945 in the report of Vannevar Bush, Science, the Endless Frontier. During the period in which the Congress was considering the recommendations of that report, the Office of Naval Research, the National Institutes of Health, the Atomic Energy Commission, and other agencies established and supported vigorous research programs in relation to their own missions. An important component was support of research in universities. There were thus established ties between the Nation's universities and the several Federal agencies—ties which have been especially cultivated by the Foundation—and these relationships have proved to be so mutually beneficial that it is difficult to recall the time when they did not exist.

The first years of the Foundation were devoted principally to its own support activities. In the coordinate Foundation responsibility for the pursuit of science policy, early attention was given to statistical studies and analyses on national research and development investment and on questions related to scientific and engineering personnel.

In all the research programs, emphasis was placed on giving assistance to individual scientists of high creative ability. The technique of review of research proposals by panels of the proposing scientists' peers was established. The project method was adopted—after close scrutiny of alternatives—and has been found to have considerable merit for the Foundation. In the early days of minimal budgets, it provided a means for maximizing the immediate research return for the support dollar. The project grant is still the Foundation's major means of supporting research. Let me interject here that when I speak of research or science in this talk, I mean it to include not only the physical and biological sciences but also mathematics, engineering, and the social sciences.

The other major activity initiated in the Foundation's early days was the awarding of graduate fellowships. In accordance with the act, these awards were made to highly selected young men and women on the basis of ability and were open to all citizens. Today the Foundation awards a variety of fellowships for both students and teachers, ranging all the way from predoctoral students to senior scientists of established reputation.

These two activities—the support of basic research by means of project grants and the award of fellowships—remain as two of the major program activities of the Foundation, but over the years they have been supplemented by many new activities. Rather than present a chronology for these new efforts, I believe it would be of more value if I now discuss them as they are today.

In its support of research and science education, the Foundation has chosen, wisely, I believe, to continue to stress investment in people as a broad element of the strategic approach to helping science move forward. Science advances through the creative efforts of well-educated, gifted people. Identification of such people and appropriate support for their endeavors constitute a logical approach to assuring that progress will indeed take place. This investment is made primarily through the country's institutions of higher learning by—

(1) Support for high-quality research at a level which encourages necessary growth in the research activities of academic institutions;

(2) Support for individual and cooperative programs to increase research emphasis on scientific areas of national interest, such as oceanography and the atmospheric sciences;

(3) Promoting the attainment of higher quality in science education;

(4) Measures to attract sufficient numbers of talented students to undertake careers in science, and to encourage the achievement of excellence by individuals; and

(5) Efforts to stimulate the growth of existing centers of scientific excellence and encourage new centers wherever this is feasible.

As I have stated, our major mechanism for supporting research today, as in 1951, is the project grant given in response to individual proposals and not fitted into any particular pattern. However, the Foundation's programs have become more varied and now include certain especially identified, concerted efforts.

The first group is a class of so-called national research programs, usually of an interdisciplinary nature, which are conducted in pur-

suit of concerted national or scientific goals and which pose special problems—problems which may relate to geography, funding, equipment, manpower, or simply magnitude of effort. They are normally supported by means of project grants, as in our regular research support activity, but are given identity and emphasis by means of the selection and collection of research support into concerted programs.

NSF's first venture in this direction was in the role of providing support—on behalf of the entire Government—for the International Geophysical Year. With advice from the National Academy of Sciences and special funds provided by the Congress, this program was launched as part of a carefully coordinated, worldwide research effort designed to provide a fuller understanding of the earth and its environment. Geophysicists and others are still analyzing and working with the vast store of scientific information which was obtained during that intensive period of observation.

A current example is the support being provided for the Antarctic research program where NSF both coordinates and funds the U.S. component of the international scientific activities on and near the south polar continent. Logistic support is provided by the Department of Defense, and the Department of State serves in dealing with the international aspects of the program.

Another novel endeavor is the large-scale experiment to pierce the earth's crust by drilling through the ocean's floor, Project Mohole. The immense scientific potentialities of this enterprise have at times been somewhat obscured by the new and exciting technological aspects it presents. Despite its being fraught with technical difficulties which challenge our most advanced engineering capabilities, the project is worthy of man's imagination and creative endeavor—and of Government support. This project, which at present is in the stage of developing facilities, has some of the characteristics of NSF's national research centers which I will describe shortly, except that in this case—if I may make a pun—when the platform is operational it will be a sort of "roving center."

In addition to supporting the conduct of research, the Foundation also grants funds to universities and other research institutions for highly specialized—sometimes unique—research facilities, as well as major items of research equipment, such as nuclear accelerators, oceanographic vessels and shore facilities, specialized biological laboratories, and large laboratory equipment. The absence or inadequacy of facilities and equipment at many institutions is a key limiting factor in the advancement of research, and the resources of most institutions are inadequate to acquire the needed facilities without Federal assistance. The provision of the essential tools of research serves to make research scientists more productive and often makes possible investigations which could not otherwise be carried out.

In certain fields there is need for research facilities which are so expensive in money and effort that they can be afforded only singly or in very small numbers, but which should be available for use by scientists from many institutions. To meet this, and in some instances other needs, the Foundation has established and supports national research centers. For example, in the late 1950's it became apparent that progress in astronomical research was being limited in this country by the relative scarcity—and in some cases the unavailability—

of major observing facilities. Aware of this problem, the Foundation set up special mechanisms to study possible solutions and as a result of careful consideration decided to establish national observatories patterned in concept after certain of the national laboratories of the Atomic Energy Commission. Today there exist two national astronomical observatories in the United States: the National Radio Astronomy Observatory at Green Bank, W. Va., and the Kitt Peak National Observatory in Arizona in the optical field. So that American astronomers may have a facility for observing the parts of the universe which are visible only from the Southern Hemisphere, a third national astronomical facility, the Cerre Tololo Observatory, is being funded by NSF in the Chilean mountains of South America.

Another center is the National Center for Atmospheric Research at Boulder, Colo., which is in response to the need for a concerted attack by many scientists on problems of the atmosphere as well as to the need for centralized facilities and services. It operates balloon and aircraft facilities and provides specialized equipment. These national centers provide modern facilities for use by significant numbers of visiting university scientists and by graduate students, as well as regular permanent staff, and thus constitute effective extensions of university research activities. They are operated for the Foundation under contract with nonprofit corporations sponsored by groups of universities.

Just as new activities have been introduced for the support of research, new mechanisms have been developed to enable the Foundation to discharge more fully its responsibility for science education. We are interested in improving such education at every level, from primary school, through postdoctoral study, and even to the further learning which senior scientists need in order to maintain their creativity. Generally speaking, the various programs have three objectives: to assist qualified individuals to obtain additional advanced training or partake in additional activities, to improve the quality of material that is taught and the methods that are used in teaching it, and to improve the knowledge and other qualifications of the teachers. Let me now discuss briefly some of our efforts in these areas.

I have previously mentioned the various kinds of fellowships which the Foundation now offers to individuals. These include a continuation of the Foundation's original graduate fellowship program, an activity which has been and is regarded as one of our most effective efforts; the awards in this case are made directly to students on the basis of merit in open national competition. Our cooperative graduate fellowships were introduced in 1958 and are awarded to graduate students who apply through the universities which they attend. We have two postdoctoral fellowship programs which provide for advanced training and study for especially able individuals who wish to become still more effective as investigators. Our science faculty fellowships provide support to university and college science teachers for study and work to meet their individual needs, with the primary aim of making them more effective teachers of undergraduate students.

A complementary activity is the support of graduate trainees. The objective of this program is to increase the number of qualified individuals working toward advanced degrees by more fully utilizing

graduate training facilities throughout the Nation. To achieve this the trainees are supported through grants given to universities which can accommodate increased numbers of graduate students who are selected by the grantee institution.

At the undergraduate level a program has been designed which provides opportunities for undergraduates to participate in significant research under the guidance of senior scientists. The number of such undergraduate research participants is about 6,200 annually. Some 37,000 students have been supported since the program's initiation.

A closely related activity is the effort to provide colleges and universities with undergraduate instructional equipment. Here, we match funds with the institution to assist in the purchase of much-needed equipment to provide adequate laboratory training for undergraduates. This equipment support activity has had a widespread influence throughout the Nation and has helped a large number of small colleges as well as the institutions that train most of our undergraduate majors in science. About 950 grants are given each year to some 530 institutions.

A special activity which has a multiplier effect is our 12-year-old "institutes" program which seeks to upgrade the teachers of science. Institutes are group training activities in science, mathematics, and engineering for teachers of these subjects from the elementary to the undergraduate level with special emphasis so far on the secondary schools. These activities are organized and conducted by several hundred universities and colleges. Institutes are conducted in the summer, and during the school year for inservice teachers. A smaller number of so-called academic year institutes give training to teachers who have taken a leave of absence for a year. Stipends are given to teachers enrolled in the summer and the academic year institutes.

Funds provided by the National Science Foundation this year will make it possible for more than 42,000 teachers to obtain subject matter training which makes them better teachers. Since these activities were initiated about 300,000 such teacher trainee opportunities have been provided. However, the number of individuals affected is considerably smaller since many teachers have partaken in more than one institute. Incidentally, activities of the institute type are now being employed by the Office of Education mainly in nonscience fields.

A most unusual—and successful—activity is that for course content improvement. Grants are made to outstanding scientists and teachers to work together to modernize and improve the content of science courses at both the precollege and the undergraduate levels. These groups have incorporated the latest scientific ideas into texbooks used in lectures and laboratory classrooms, and equipment used to demonstrate the principles of science.

Because of our science education programs have been designed to help solve a number of problems, the Foundation currently supports quite a few other educationally oriented activities. I want to emphasize that our concern in science education is directed primarily at the qualitative aspects—at intensifying the experience and making more effective the work of students and teachers undergoing science training. We are involved in experiments and innovations to improve the learning process—and we intend to continue to stress the role of NSF

as a trailbreaker in this area. In our discussions a bit later we can deal with some of those other elements.

Let me turn now to another important set of activities, each of which supports both research and science education. Here I refer to our direct support of academic institutions, primarily universities, in order to strengthen their research and science education capabilities.

To meet the critical need for graduate laboratory facilities, the Foundation undertakes to match funds for such items as the construction of new—or the renovation of existing—research laboratories and the acquisition of apparatus required for advanced training and research projects. More than 100 grants for such purposes are now being given each year.

For the past 5 years (under a separate program), support has been given to educational institutions in the form of institutional base grants—an annual grant of funds based on a tapered formula related to the research support which these institutions receive from the Foundation. The tapering is such as relatively to favor those institutions receiving the least support. Under present policy grants range in size from small amounts to a maximum of $150,000. These institutional base grants may be used for any purpose which directly supports academic science, and thus provide funds for such items as rental costs for general use computers, equiping shops, library acquisitions, student stipends, and many other purposes. This type of support provides a highly desirable and helpful degree of flexibility to universities and colleges, thus overcoming to some extent certain difficulties inherent in the project grant system which I shall discuss later.

The Foundation's newest technique of institutional support is the science development grant. Hereby means of grants of a few million dollars each, NSF is seeking to increase the number of outstanding educational institutions and to accelerate the development of schools of known quality and acknowledged potential. Proposals for such grants must be built upon well-developed plans to produce substantial upgrading in the quality of some significant segment of the institution's science activities. Grants of 3-year duration are made to institutions judged to have the greatest potential for moving upward to and maintaining a high level of scientific quality. We have spent a great deal of time in clarifying the goals and selecting criteria for this program. We recently announced the first four science development grants to the University of Oregon, Washington University in St. Louis, and Western Reserve University and the Case Institute of Technology in Cleveland, Ohio, the last two being in accordance with closely coordinated plans. We hope to award several more grants shortly.

The Foundation has a special responsibility for fostering activities to assure widespread dissemination and effective utilization of research findings. Moreover, our science information program is one of the areas in which the Foundation has been authorized by Congress to extend its support beyond basic research. NSF's science information programs do not involve large expenditures, but they are broad in impact; they include support of activities in basic research, applied research and testing, all directed at improving the methods of disseminating science information, as well as a number of activities

designed to assure effective dissemination to U.S. scientists of research results, no matter where in the world they have been achieved and no matter in what language they were published.

Two activities deserve special mention. The first is the wide support provided for the translation and dissemination of foreign science information. Grants are made to scientific societies to select, translate, and publish the research appearing in the foreign scientific literature in the field of their interest. In addition contracts have been made with organizations in Poland, Israel, and Yugoslavia for the regular translation of books and periodicals from Russian into English. Payment for these services is made in counterpart currencies.

The second is a developmental program, jointly funded by NIH, DOD, and NSF, aimed at providing a much-needed, high-speed source of chemical information for scientists. The project will establish a computer-based registry system for chemical compounds which will ultimately serve chemists throughout the Nation. The program is a pioneering effort in Government interagency coordination in the information systems field.

To this point I have been discussing NSF activities in support of science. Through such efforts, we make available more than 95 percent of our annual appropriation to advance scientific knowledge and to build our strength in science education. I now turn to a rather different function.

The original act authorized and directed the Foundation to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences. Pursuant to this obligation the Foundation early in its life engaged in a program of gathering statistics with respect to scientific manpower and basic research. These data, most of which had not previously existed, have provided an ever-increasing base upon which to study problems related to national science policies. In carrying out its policy function, the Foundation has issued reports, such as "Basic Research a National Resource" (1957), "Government-University Relationships in Federally Supported Scientific Research and Development" (1958), and "Investing in Scientific Progress" (1961), which attempt to place the growing needs of science in perspective.

By Reorganization Plan No. 2, in 1962 there was transferred to the Director of the newly established Office of Science and Technology so much of the Foundation's policy function as is necessary to enable that official to advise and assist the President in achieving coordinated Federal policies for the promotion of basic research and education in the sciences.

I might interject, Mr. Chairman, that a committee of the National Science Board gave considerable advice to the executive branch that led to this reorganization plan. There was a study by a special committee of the Board.

At the same time the President stated that the Foundation would continue to originate policy proposals and recommendations concerning the support of basic research and education in the sciences, and that the Office of Science and Technology would look to the Foundation to provide studies and information on which sound national policies in science and technology could be based. The Foundation has, therefore, not only put a great deal of effort into serving the needs

of the Office of Science and Technology and the Federal Council for Science and Technology, but has also continued to consider and make recommendations, when appropriate, on policy matters; in order to accomplish these ends, it has also expanded its factfinding and analysis function, and has recently given this function a greatly enhanced organizational position. Now that we have gathered and have at hand a more nearly adequate base of information, we believe we can launch a major effort to isolate particular roadblocks and problems in the path of the Nation's scientific development—and thus assist more effectively in the development of policies to assure healthy scientific progress for the country.

This necessarily incomplete discussion has, I hope, given some idea of the scope and general nature of our activities. The administration of these activities has been assigned to senior members of the staff who have been instructed—in line with the policy of the President to improve efficiency by eliminating needless and bureaucratic practices—to seek simple and effective means for strengthening the Foundation's programs. I believe we are effectively implementing this policy.

With your permission, I should now like to present and discuss some visual materials which I believe will help to convey the current status of the Foundation, its place among the several Federal science agencies, and the size and scope of its current activities.

Mr. Daddario. Go right ahead, please.

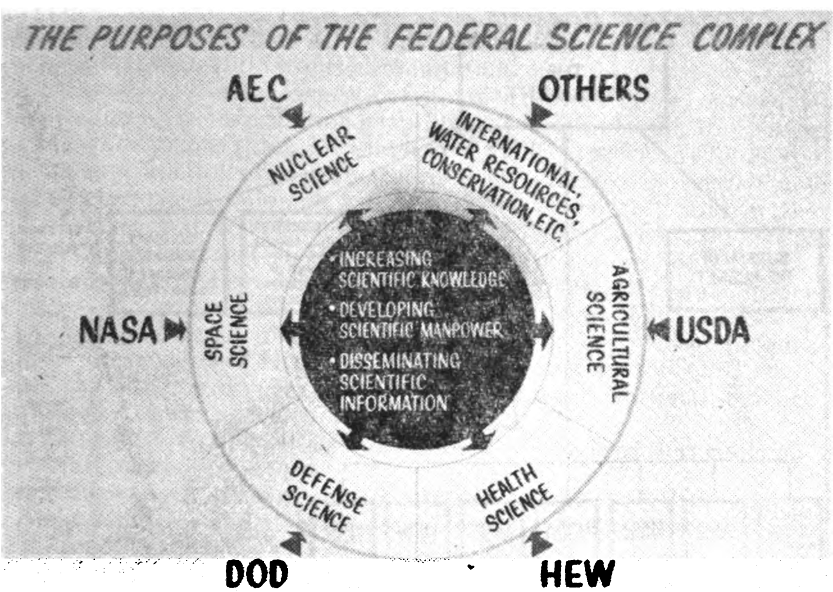


Chart 2

Dr. Haworth. I would like first to discuss very briefly the content of chart 2, "The Purposes of the Federal Science Complex." I note in the prepared text the way in which basic research and applied research are the underpinning for all the practical applications in

science. I am speaking here of the practical rather than of the cultural aspects. This chart is an attempt to diagram the relationship of basic science to the practical objectives of the various agencies.

The central part of this diagram represents the sources, the wellsprings of our advance in science, and it is, of course, in this area of increasing scientific knowledge, of developing manpower, and of helping to disseminate information that the Science Foundation works.

Now, many other agencies work in this area, too; in fact, all of the technical agencies do. All of the agencies support basic research. All of them, directly or indirectly, have an impact on developing scientific manpower.

The underlying—and perhaps I should define "underlying" in such a way as to include at least some elements of applied research—the underlying activities in the center of the diagram impact outward and are useful in all the more specific applied and developmental areas, such as space, defense, the nuclear sciences, and so forth, where the agencies indicated around the edge of the circle are particularly concerned. So, this is meant to show that there is a complete interrelationship between parts of this complex. The inner portion represents the basic underpinnings; the outer sections represent the applications, and the agencies shown are those particularly interested in the applications, although every one of these agencies also finds itself within this inner circle.

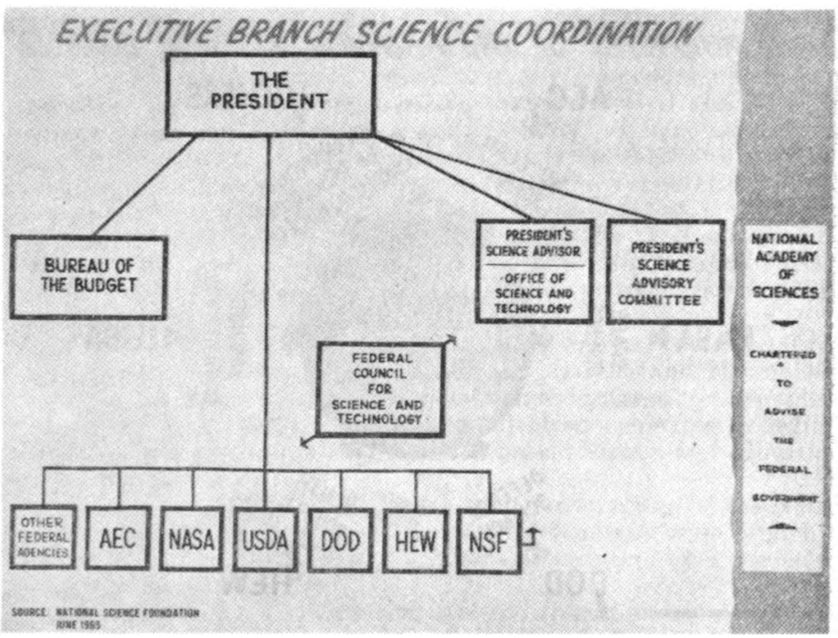


CHART 3

Chart 3, "Executive Branch Science Coordination," is a crude indication of the relationship within the executive branch of the activities of the various agencies. All, of course, report to the President.

The President is served on the one hand by the Bureau of the Budget and on the other by the President's science adviser, who is also the Director of OST. The President is also advised by the President's Science Advisory Committee, of which traditionally the science adviser is the Chairman.

In addition there is the Federal Council for Science and Technology, made up of a single representative from each one of the agencies primarily concerned with science or technology, that is with research and development. The Council is also chaired by the science adviser. This Council serves as the coordinating body for the whole group of agencies, not only among themselves but with the White House. It is concerned with both the formulation and suggestion of policy and also the coordination of particular programs. It has many subpanels on such subjects as oceanography, planetary sciences, science information, and so forth.

The arrow leading up from NSF is meant to indicate that NSF has by statute a special role over and above the other agencies with respect to collecting the kind of information that I spoke of earlier and suggesting policy. This simply means that NSF feeds back to the executive offices, the FCST, et cetera, the results of its studies and the suggestions that it has.

Mr. Daddario. Do you mean that at the time the policy function referred to under the Reorganization Plan No. 2 was transferred to OST, some of it was retained by the National Science Foundation?

Dr. Haworth. That is right.

Mr. Daddario. So, there is an interrelationship, although it is not now a prime responsibility of the Foundation.

Dr. Haworth. Certain aspects of it are still, in a sense, our prime responsibility—the information gathering, for example, the Manpower Register, and various things of that sort. NSF never was assigned the coordinating function even in the original act. Let us say the primary initiative for the development of policy is, of course, now in the Office of Science and Technology. Originally, NSF was supposed to study and encourage—I don't remember the exact words of the act—national science policy, which includes, of course, Federal science policy, but that part of the original NSF assignment that is necessary for OST to advise the President on what kinds of Federal policies ought to be developed has now been transferred to the OST. Of course, the OST didn't exist when the original National Science Foundation Act was passed.

Mr. Daddario. Could we say that, in a sense, a little of that responsibility is left over?

Dr. Haworth. A little of that is left over. There is both the question of how much—and it is somewhat intangible I have to admit—is an assigned responsibility in the legal sense, in the formal sense, and how much takes place just by tradition and relationships and so forth. I think it is fair to say that OST, Dr. Hornig and his office, look unusually strongly to the NSF for assistance in helping them develop information and policy both for OST and for the Federal Council; so, we are simply more engaged in this than are other agencies.

Mr. Miller. Isn't that brought about, too, by reason of the fact that most of the other agencies—AEC, NASA, Agriculture, Defense,

HEW—have fairly specific missions and the Foundation must come in and fill the gap between these missions?

Dr. HAWORTH. That is right, and that, of course, was the reason for the original provision in the act, at least I so assume.

Mr. CONABLE. Would you still stand by this chart putting NSF down the line from the other agencies when it has a coordinating function in gathering information for the other agencies?

Dr. HAWORTH. NSF has two roles: it is an operating agency, it supports research, it has national centers, it supports research in the universities, and so on; just like the other agencies do.

It also has this somewhat special responsibility for assisting in the collection of pertinent information, for making analytical studies, and for making suggestions with respect to policy. That is what I meant to indicate by this arrow. NSF wears two hats; that is about as good a way of saying it as any.

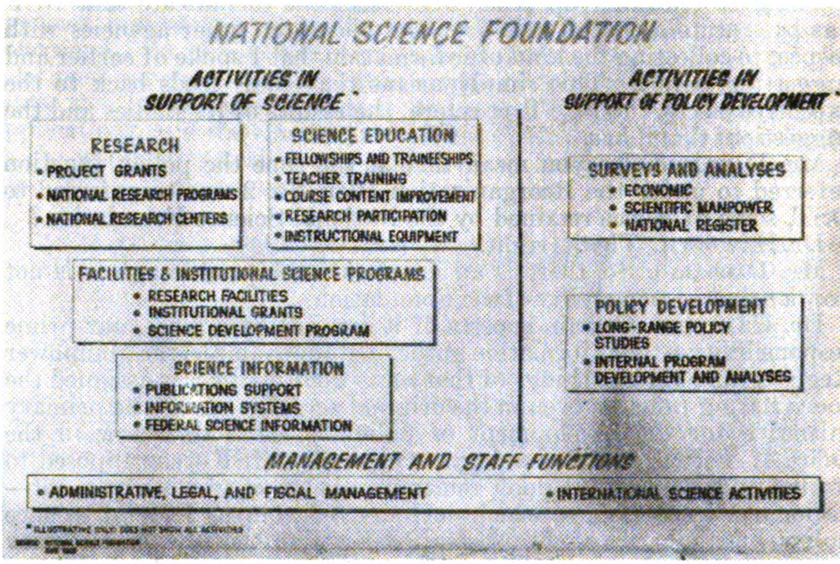


CHART 1

I would like to call your attention now to chart 1, "National Science Foundation Activities in Support of Science and Science Policy Development." This simply shows in highly schematic form the various activities of the Foundation, nearly all of which are outlined in the prepared statement:

> Research, which, as I said, is carried out through project grants, national research programs, and national research centers;
>
> The various science education activities, which are somewhat condensed here;
>
> The support of institutions; that is, the support that isn't in the form of project grants for the conduct of research but rather for other things such as laboratories, institutional base grants, and the science development program; and

Science information, which is important to research, to the progress of research, but is not, except in the sense of research on information processes themselves, in itself research. Rather, it is seeing that appropriate use is made of the results of research.

Then, there are the surveys and analyses that I spoke of, the policy development activities, which, of course, have to include development of our own policies and programs as well as the broader responsibility that we were speaking about a few minutes before.

Then, cutting across the whole thing, there are our own management and staff functions, which include the usual administrative activities of any agency.

We are involved to some extent in international activities, which thread through these other programs. We have a staff office that coordinates those international activities in which we are engaged but doesn't itself support them, the support coming from the science programs.

We can leave chart 1 out all the time and refer back to it from time to time as I come to various parts of the program.

Mr. DADDARIO. Dr. Haworth, on your chart you refer to fellowships, and on page 13 of your statement you talk about them in reference to their being based on merit in open national competition. Yet, there are limitations geographically, are there not?

Dr. HAWORTH. Yes.

Mr. DADDARIO. If there are, how does that work harmoniously with the idea of their being based on merit in open national competition?

Dr. HAWORTH. By the fact that from the beginning the Foundation was empowered and directed by the act to provide fellowships with the following instructions:

(1) The individuals would be chosen on the basis of merit;

(2) They would be free to go to the institution of their choice; and

(3) That other things being equal, one should take into account geographic distribution.

I don't remember the exact words, but, in effect, the act says that if two or more applicants are judged to be equal in merit, and you cannot give a fellowship to all because of limitation on funds, then you should choose the one or ones who would help to give a wide geographical distribution.

The way that is handled in the so-called graduate fellowship program, which was the first NSF fellowship program, is that the applicants are placed in what are called quality groups. Group 1 is judged to be the highest ability individuals; group 2 the next, and of substantially equal ability; and so forth.

Obviously, this is a subjective thing in many ways. First, fellowships are given to all the people in group 1. Group 1 is chosen to be small enough so that this can be done. Then, say, there are not enough available fellowships to cover all the people in group 2. You select those in a way to achieve a reasonable geographic distribution.

Mr. DADDARIO. Do you think that even though there is that barrier to being just on merit alone, it does work out properly, and it does achieve its objectives?

Dr. HAWORTH. Yes; I think so. In principle it is not a barrier because you are selecting from among a group judged to be of substantially equal ability. Instead of flipping a coin to break ties, you note that several people in group 1 from this State and that State have received fellowships, but only a few individuals from some other States have received any. Your first awards from group 2 then would be made to individuals from "deficient States."

Mr. DADDARIO. Congress is adding to the barrier, as I put it, by imposing a percentage limitation, is it not?

Dr. HAWORTH. The House appropriation bill this year did; yes.

Mr. DADDARIO. Is it an inhibiting factor to getting the type of quality that you would like to have?

Dr. HAWORTH. That would be a barrier. We would be forced to give some fellowships to people who were in a lower quality group than others who did not get them.

Mr. DADDARIO. Rather than in the method of balance that you have achieved up to this point?

Dr. HAWORTH. For example, Mr. Chairman, this year in quality group 2—I am speaking now of this graduate fellowship program, which is our blue ribbon fellowship program—there were about—if I remember rightly—650 people in it, but we had funds to support only 330 people in this quality group. Among those 650, there were 96 who listed New York State as their State of permanent residence. Now, if you selected at random, you would expect that half of these 96 from New York State in quality group 2 would have received fellowships, if we had disregarded considerations of geography. As it was, in this year's competition we were unable to make a single award to a New York State resident from quality group 2. Under the restriction of the House bill, we would have had to cut back the awards to New Yorkers even more. We would have had to reduce the number of awards to New Yorkers in quality group 1 by about 37 percent and we would have had to award these fellowships to residents of other States who had been judged to be in a lower quality group.

Mr. MOSHER. When you are talking about geographic distribution, are you talking about the residences of the people?

Dr. HAWORTH. I am speaking on the basis of what the people declare their residence to be.

Mr. MOSHER. Rather than the campus on which they do their work?

Dr. HAWORTH. Rather than the campus. The act is very explicit on that. They are permitted to go to the university of their choice. I am speaking now in terms of a State of permanent residence, although this is kind of fuzzy, because, as you know, many students, especially by the time they become graduate students, declare their residence to be wherever they are going to school.

Mr. CONABLE. Under the new bill there would be no New York students because they are so many New Yorkers in group 1?

Dr. HAWORTH. That is right. New York has about 10 percent of the population. A bigger than average fraction go to college. As a matter of fact, the number we have traditionally given in New York State, or any other State, is very closely proportional to how many residents of that State are in graduate school, how many graduates

in that State are getting Ph. D.'s, and so forth. There is a remarkable uniformity in that respect.

For example, about 17 percent of the graduate students in science and engineering in the United States say they are residents of New York State. Well, we gave about 15 percent of the graduate fellowships to residents of New York State.

Mr. DADDARIO. I imagine California would be similarly affected as New York in the near future?

Dr. HAWORTH. Yes, but not by such an amount. At the moment they do not have as large a fraction as New York State. If any limit was set, it would affect them but in a more limited way compared to New York State.

Mr. MOSHER. Actually, these New Yorkers would be spread over a large geographic territory in the location of their campuses?

Dr. HAWORTH. Yes and no. The graduate fellowship holders tend to concentrate in a relatively few universities. That is where the real concentration is, in their choice of where to go, and they choose to go to Harvard, MIT, Chicago, Stanford, and so on. But the thing that one must remember about all of this is that what really counts is where they go afterward. These universities are not local universities, they are national universities. For example, in the freshman class at MIT, only 11 percent of the students come from the State of Massachusetts—the remainder come from all over the country. By the time they get to be seniors about 20 percent of them say they live in Massachusetts, but this is just because they changed their State of residence. After they graduate they fan out to many graduate schools, of course, and after they get their advanced degrees, that is, those who do, then they fan out all over the country. There are people who study at MIT from every State in the Union. So, we have to think of the matter in this way.

The thing I fully agree we must do—and it will apply not only to fellowships, particularly, but also to the whole situation—is we must be sure, as best we can, that a bright youngster from one part of the country has just as good a chance to climb up the ladder as a youngster from any other part of the country. That is the real problem.

Part of the trouble is that there could be two people of equal potential, say, one in New York State and one in some other part of the country without as good an educational system. The one from New York State gets good training through elementary and high school and undergraduate school—gets better training than the other fellow—so he just naturally has a better chance in a national competition, not because he is intrinsically any better, but because his background is better.

Mr. MILLER. Isn't that our big problem today. We must try to raise the standards of primary and secondary education to wipe out these deserts?

Dr. HAWORTH. Yes, I think that is the big problem up through college, but we should meet it by lifting the standards——

Mr. MILLER. Not by leveling them off.

Dr. HAWORTH. Not by leveling off. By lifting, not by bulldozing.

Mr. CONABLE. Not by penalizing New York.

Dr. HAWORTH. That is right.

So, we will just leave chart 1 here, and I will undoubtedly refer to it from time to time.

Next, I thought it might be worthwhile to give the total national picture and the total Federal picture in order to fit NSF into context. Some of these are things I said to you nearly 2 years ago, but I think that to have them freshly in mind might be worthwhile. I will speak more briefly than I did at that time when I gave a more general presentation.

First, let's look at chart 4, "Funds Used for Research, Development, and R. & D. Plant, by Source of Funds, 1963." I will take up funding for research and development in the national sense now, not just Federal funding, but the total funding, and come to education later. Unfortunately, calendar year 1963 is the last year for which we have sufficiently detailed data because we have to get reports from outside the Government as well as inside to be able to give you total figures.

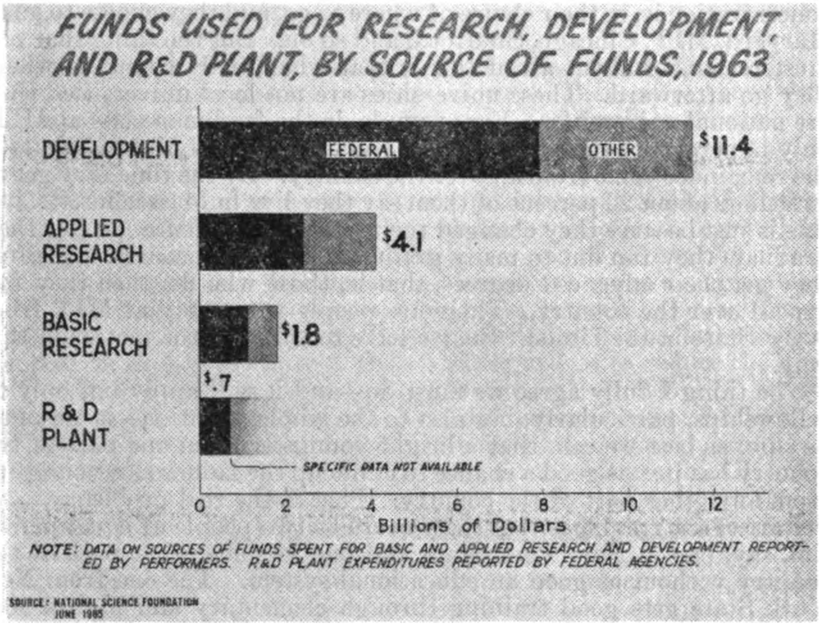


CHART 4

In 1963, for research and development, and R. & D. plant, something more than $17 billion was spent. Now, we can't be precise about it because we do not have figures from industry, for example, on their expenditures for R. & D. plant. In many cases companies do not know themselves, because when they build a building, it may be partly for R. & D. and partly for something else, and it is pretty hard to pro rate the cost.

If you include everything spent for development, and for applied and basic research, then the Government component for R. & D. is some $11.4 billion. In addition, Federal obligations for R. & D. plant were $7 billion. There is an undetermined amount for R. & D. plant from industry and universities.

As you can see, the solid part shows the Federal share of each component, and the cross-hatched part, the outlays, by the others, primarily industry, secondarily the universities.

Of course, development is carried on primarily by industry. Federal financing of development is just under $8 billion, and all other financing, around $3½ billion. Thus, of the $11.4 billion for development, the Federal Government is funding a little less than 70 percent.

There is a total of $4.1 billion for applied research. Admittedly the boundary lines between development, applied research, and basic research are very, very fuzzy. I don't know how to say sharply this is applied research and this is basic research, and I don't think anyone else does. You give the best definitions you can, and respondents classify their activities for NSF surveys as well as they can. In the field of applied research the Federal Government is supplying about 60 percent, a little smaller fraction than for development.

In basic research the Federal Government is supporting $1.1 billion out of $1.8 billion, which would be a bit over 60 percent.

It is interesting that in development the Federal Government provides a bigger fraction than in applied research and basic research.

RESEARCH AND DEVELOPMENT, 1963

Intersectoral Transfers of Funds Used for Performance (Preliminary)

(Millions of Dollars)

SOURCES OF FUNDS USED	RESEARCH AND DEVELOPMENT PERFORMERS						PERCENT DISTRIBUTION, R&D SOURCES
	FEDERAL GOVERNMENT	INDUSTRY	COLLEGES & UNIVERSITIES: PROPER [a]	COLLEGES & UNIVERSITIES: FED'L. CONTR. RESEARCH CENTERS	OTHER NONPROFIT INSTITUTIONS	TOTAL	
FEDERAL GOVERNMENT	2,400	7,340 [b]	775	525	300 [b]	11,340	65
INDUSTRY	—	5,380	65	—	120	5,565	32
COLLEGES & UNIVERSITIES [c] ...	—	—	260	—	—	260	2
OTHER NONPROFIT INSTITUTIONS [c] ...	—	—	75	—	110	185	1
TOTAL	2,400	12,720 [b]	1,175	525	530 [b]	17,360	100
PERCENT DISTRIBUTION, R&D PERFORMANCE	14	73	7	3	3	100	

[a] Includes Agricultural Experiment Stations

[b] This Amount Includes Funds from the Federal Government for Research Centers Administered by Organizations Under Contract with Federal Agencies

[c] Data Include State and Local Government Funds

NOTE: Data are Based on Reports by Performers

Source: National Science Foundation, 1964

CHART 5

Chart 5, "Research and Development, 1963," shows on the one hand where funds originate and on the other where they are used. For example, the top line shows that of the total spent for research and development in 1963, the Federal Government provided $11.34 billion. Of that around $2.4 billion was spent in-house; $7.34 billion was spent by industry; $0.775 billion by the colleges and universities proper—and you are familiar with what I mean by that—$0.525 billion in the Federal contract research centers at universities, such as Los Alamos,

Jet Propulsion Laboratory, and so on; and \$0.3 billion by other non-profit institutions. It can be seen that the Federal Government provided about 65 percent of the total spent on research and development. R. & D. plant is not included in the data.

Let me break down one column here, the universities proper, because I am going to emphasize considerably the universities and colleges. In that year they spent an estimated \$1.175 billion on research and development—nearly all research, of course. Although an appreciable component was applied research, very little was development. The Federal Government provided an estimated \$0.775 billion of the total; industry provided \$0.065 billion through gifts or grants or contracts. The colleges and universities themselves provided about \$0.26 billion, which was about 22 percent of the total, and the rest came from foundations and other private sources.

This \$0.26 billion, of course, includes other public funds, because both the direct and indirect support given by State or local governments to research in colleges and universities is included in that line. The \$0.775 billion is only the contribution of the Federal Government.

I would like to credit the staff member who, some time ago, devised this way of displaying the data. I think it is a very useful form of presentation—a snapshot picture in certain dimensions.

Mr. MILLER. Dr. Haworth, the chart shows that about two-thirds of the funds used by the colleges and universities came from the Federal Government.

Dr. HAWORTH. For the support of research; yes. That is right.

Mr. MILLER. The Federal Government put up about 75 percent of the money, the States, apparently about \$0.26 billion, and the——

Dr. HAWORTH. The States and the private sources.

Mr. MILLER. The private sources?

Dr. HAWORTH. The endowments and so on of the private universities.

Mr. MILLER. Still, the burden of it is on the Federal Government?

Dr. HAWORTH. That is right.

Now, I should hasten to say that one thing that in my opinion does not completely show here is the many hidden costs that just do not get on the books. I don't mean just overhead costs, but all sorts of unrecorded costs. So, I think it would be fair to say that roughly a quarter of the funds for university-performed research is provided by the universities themselves, including public support and private support.

Mr. MILLER. Substantially all of the facilities are provided by the colleges and the universities?

Dr. HAWORTH. That is right.

Mr. MILLER. They cannot be evaluated?

Dr. HAWORTH. That is right. Those facilities have been built up over the years, of course. This is one of the very important things. If the universities hadn't been there and hadn't built up their facilities and their faculties, and so forth, we wouldn't have this resource to turn to.

Chart 6, "Trends in Federal Obligations for Basic and Applied Research, Development and R. & D. Plant," shows some of the trends in our Federal R. & D., from fiscal years 1956 to 1965. The top line

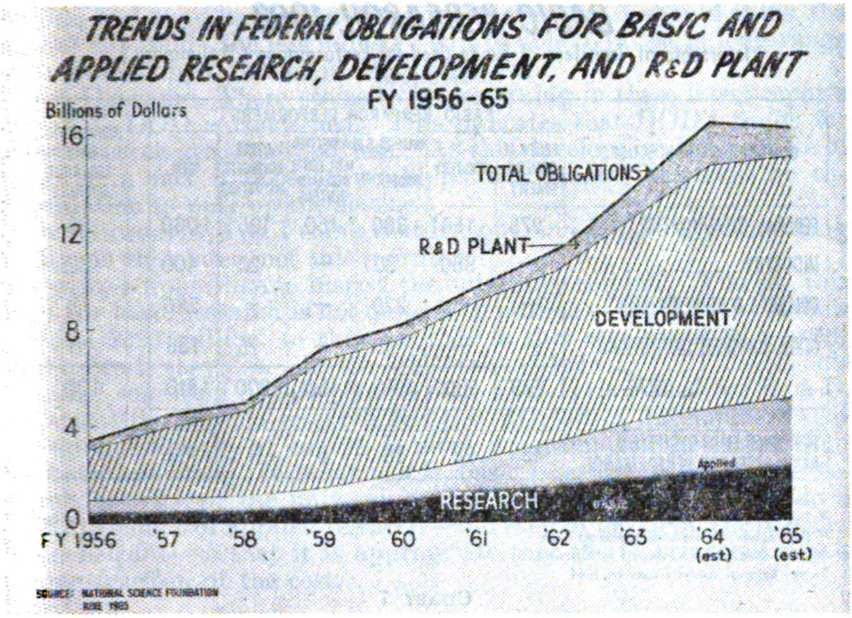


CHART 6

represents the overall Federal total as it has grown over the years, with corresponding trends for the components. You can see, as you well know, that the Federal research, development, and R. & D. plant total has grown very substantially over the last decade, but that there is a little tendency to level off in the last couple of years. The R. & D. plant total has perhaps leveled a little more than anything else.

We have indicated that you cannot sharply separate basic and applied research. The distinction is fuzzy. If you take the figures that have been collected—these are Federal agency estimates for 1964 and 1965—about 12 percent of the total is currently for basic research, 20 percent for applied research, 62 percent for development, and 6 percent for R. & D. plant. Thus, roughly two-thirds of the total is development.

I should hasten to say that these are estimates for fiscal year 1965. I should also point out that these are obligations and not expenditures. As a matter of fact, the expenditure line related to a rising obligations curve always lags behind the obligations. Thus, if you drew the expenditure trend line on this Federal obligations chart, the line would remain below the obligation total except in the earlier years. In other words, expenditures run about a billion dollars less than the obligations for most of the 1956–65 reporting period.

Let me turn to the component, basic research, because basic research is what the Foundation is authorized and directed to do as a primary obligation. Again, recognizing the fuzziness in the line between basic and applied research, we will look at a transfer table of the sources of funds used for the performance of basic research. Chart 7, "Basic Research, 1963," is such a table.

BASIC RESEARCH, 1963

Intersectoral Transfers of Funds Used for Performance (Preliminary)

(Millions of Dollars)

SOURCES OF FUNDS USED	BASIC RESEARCH PERFORMERS: FEDERAL GOVERNMENT	INDUSTRY	COLLEGES & UNIVERSITIES: PROPER a/	COLLEGES & UNIVERSITIES: FED'L CONTR. RESEARCH CENTERS	OTHER NONPROFIT INSTITUTIONS	TOTAL	PERCENT DISTRIBUTION, BASIC RESEARCH SOURCES
FEDERAL GOVERNMENT	275	150 b/	380	150	105 b/	1,060	58
INDUSTRY	—	350	30	—	20	400	22
COLLEGES & UNIVERSITIES c/	—	—	220	—	—	220	12
OTHER NONPROFIT INSTITUTIONS c/	—	—	60	—	75	135	8
TOTAL	275	500 b/	690	150	200 b/	1,815	100
PERCENT DISTRIBUTION, BASIC RESEARCH PERFORMANCE	15	28	38	8	11	100	

a/ Includes Agricultural Experiment Stations

b/ This Amount Includes Funds from the Federal Government for Research Centers Administered by Organizations Under Contract with Federal Agencies

c/ Data Include State and Local Government Funds

NOTE: Data are Based on Reports by Performers

Source: National Science Foundation, 1964

CHART 7

In 1963 the country spent about $1.8 billion doing basic research. Of this a bit over a billion, or 58 percent, was provided by the Federal Government, 22 percent by industry, 12 percent by the colleges and universities, 8 percent from the private foundations, and so forth. Again, in the colleges and universities line are included public funds from State and local governments which were spent on basic research.

Of the basic research, the colleges and the universities proper perform not quite 40 percent. Now, here I think one has to say that there is probably a slant to this in the final sense. I believe, with no criticism to anyone, that basic research in the universities is likely to be more basic on the whole than basic research in industry. I do not mean that industry slants its reporting or that the universities slant it, but in the spectrum from the purest research where no one can foresee any possible application, up to work that is almost applied research, industry tends to concentrate more at one end of that spectrum and the universities more at the other end of the spectrum. So, it is a matter of the distribution within basic research rather than any sharpened difference in definition. In reality I think one would say that it is probably true that the universities do a somewhat larger fraction of "pure" basic research than the data would indicate.

Mr. DADDARIO. In that regard, industry being under the compulsion to control its funds, even within the area of basic research, do you see any trends in that direction? Will the Federal Government also exercise a more controlling element to its expenditures for basic research?

Dr. HAWORTH. I do not think, Mr. Chairman, I will venture to predict. I would say it would be a natural thing to do.

It would be a natural thing, for example, for the mission-oriented agencies to do as well for industry. They have to think about getting

results, and they have immediate problems. So, I should think the tighter the funds, the less industry will be able to invest in long-range intangible things, if that is what you mean.

Mr. DADDARIO. There seems to be something in these latest reports as far as DOD is concerned. This indicates that DOD's funds for basic research are somewhat less. As this develops over the course of time, if in fact it does, it would place a greater emphasis on the Foundation to pick up the slack.

Dr. HAWORTH. Yes, I think that is right, and I will have something to say on that later, not this morning.

Again, I would like to inspect the university column. You see, this total for basic research is not quite $700 million. Of this, the schools provide $220 million, so they provide in this case about 32 percent of the funds they use. In the other table (chart 5) p. 21 the schools supplied somthing like 22 percent of the funds they used for R. & D.

Part of the applied research and the little bit of development that the universities do, of course, is more programmatic in nature than the basic research. In other words, basic research is the natural research activity of the universities, but the universities proper do a certain amount of applied research—and even of development in order to be helpful—so that it is appropriate that the Government pay a bigger fraction of the cost.

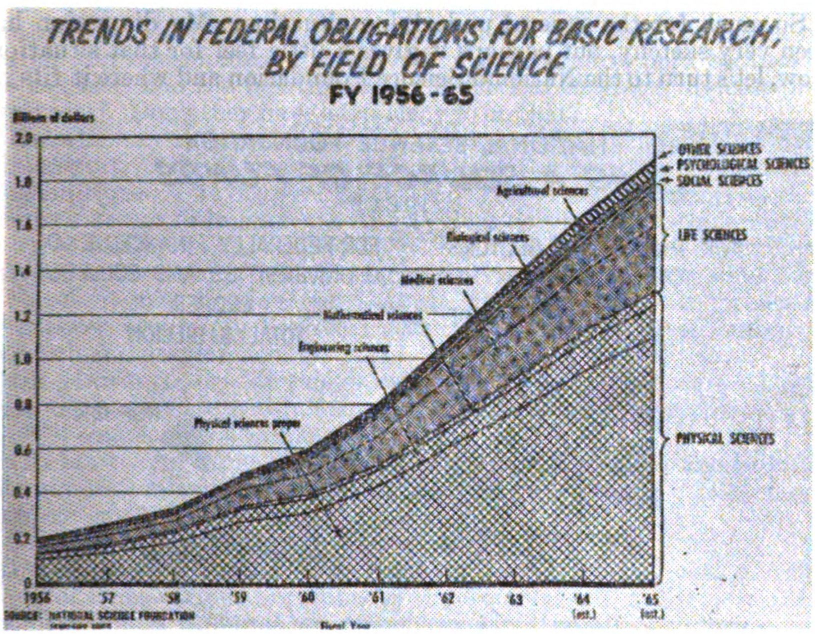


CHART 8

I have included chart 8 for two purposes: (1) to show the trend of Federal support of science and (2) to show the trend of support of various fields.

Here I wanted to show the rate of increase in Federal support of basic research, shown simply by the top line. It is quite substantial, as you see. In fact, Federal support of basic research has grown relatively more rapidly in the last 6 or 7 years than Federal support of total R. & D. I do not remember the relative numbers, but there has also been a higher relative rate of increase in basic research for the country as a whole than in total R. & D.

The other point was to give you some idea of how the support for basic research is distributed among the various disciplines. In fiscal year 1965, this distribution was estimated as follows: about $1.3 billion for the physical sciences, $485 million for the life sciences, $35 million for the social sciences, $60 million for the psychological sciences, and a $2 million scattering for other things. Thus, about 65 percent, or a little more, is in what is here broadly spoken of as the physical sciences, including not merely the physical sciences proper but engineering and mathematics. The life sciences, then, would have something like 25 percent. However, I call your attention to the fact that this is only basic research, and NIH classifies substantially more than half of its support as applied research, that is, its support of clinical research and things of that kind. Therefore, if one included not just basic research, but all research, he would find that the physical sciences would get a bit smaller fraction and the life sciences would get a bit larger fraction.

So much for the general underlying situation. My discussion has been very sketchy, but perhaps it gives a little feel for that situation. Now, let's turn to the National Science Foundation and where it fits in.

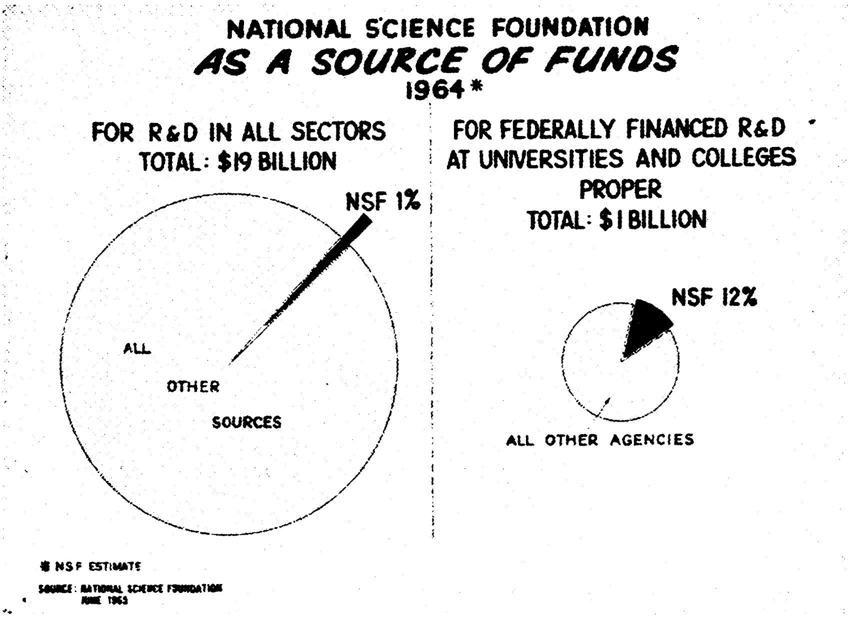


CHART 9

Chart 9, "National Science Foundation As a Source of Funds," is very schematic. It is not even dimensionally correct because if it were you couldn't see some of these things.

The National Science Foundation in 1964, according to our best estimate (circle at left), provided about 1 percent of all the research and development funds spent throughout the country, not just by the Federal Government but by all organizations. Now, if we made this graph actually to scale, the 1 percent would be merely a line, so, in terms of the total R. & D. of the country, NSF financing is pretty miniscule.

Since basic research is about one-tenth of the total R. & D. expenditure, then, if one had a diagram like this for just basic research, NSF would be supporting roughly 10 percent.

Looking at NSF in the total support of research and development at colleges and universities by all Federal agencies (circle at right), NSF supported in fiscal year 1964 an estimated 12 percent. This was about $120 million of R. & D. support in the colleges and universities. Of course, we also supported a somewhat smaller fraction of the basic research supported everywhere by the Federal Government because we don't have in-house laboratories and we don't give any appreciable support to industry. So, of the total Federal basic research it would be something like 10 percent rather than 12 percent. These are some background statistics relating us to the totality.

Mr. Conable. How much confidence do you have in the R. & D. figures for industry? Isn't there a tendency for them to charge research and development to production, for instance, both because of the tax laws and the fact that many industrial contracts are cost-plus contracts? Don't they have a tendency to do that?

Dr. Haworth. I am certainly not aware of any particular slant of that sort. I think there are difficulties with respect to the fuzziness of definitions. I have already spoken of basic research versus applied research versus development. Where does development stop and production design begin, and so on? The definitions even vary from company to company. But I am certainly not aware of any slant here.

Mr. Conable. Do you feel that the statistics you have presented here show accurately the total amount of industry contribution to research and development?

Dr. Haworth. It depends on what one means by accurate. I consider them accurate within a spread of several percentage points.

Mr. Conable. You think so?

Dr. Haworth. None of these numbers should be taken too literally except the numbers that represent how many checks the U.S. Government did write for something.

Those we can be pretty sure of.

Dr. Haworth. Let's look at chart 10 on the "Mechanisms of Support" of these various programs by the Foundation. I discussed these programs in the prepared statement, as you will recall.

Many of our programs—by no means all—clearly serve more than one function. The support of research in a university where there are graduate students clearly serves the purposes of education in several senses. The graduate students participate in research. Some of them may be supporting themselves financially or may be on fellowships and participate in order to get their doctoral thesis. Others are hired as

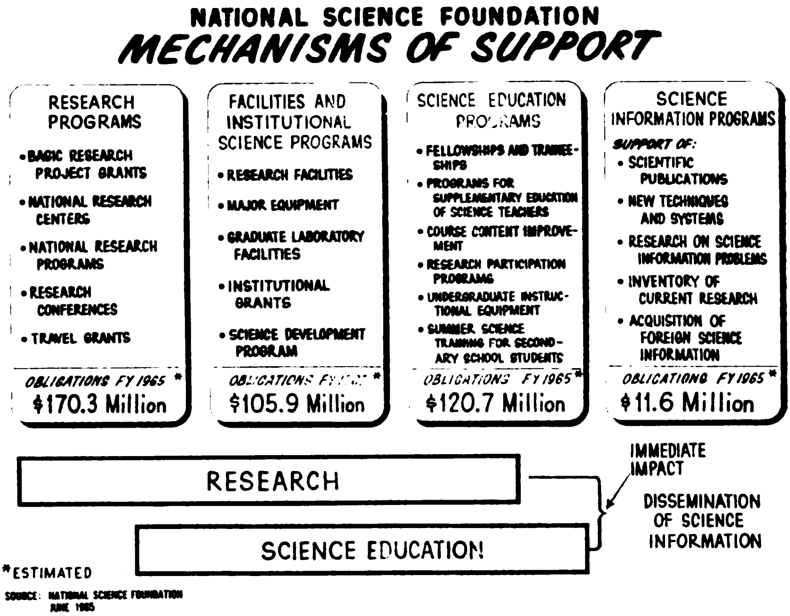


CHART 10

student assistants and participate in research. Of course, this does just about as much good as direct support for the ones who are working on their own thesis.

The fact that the faculty and those graduate students who engage in teaching are lively in their subjects, that they are up to date, and are thinking actively, and so forth, clearly has a big impact on how effective they are as teachers even of undergraduates.

So, as I said, except in some isolated instances, research funds given to universities and to some of the national laboratories—because they have visiting faculty and graduate students—have an impact on education.

Similarly, some of the science education programs have an impact on research—the fellowship programs, for example, because a substantial fraction of the fellowship holders are graduate students at the advanced stage where they are engaging in research for their doctoral thesis. We have tried to indicate by the placement of the rectangles representing the two large functions of the Foundation itself, research and education, that various activities overlie both.

I have indicated or have tried to indicate that most of the research support that we give has an impact on education. Many of the education programs have an impact on research. Then, lying in the middle and affecting both, though one cannot sort them out, are the various institutional programs, such as research facilities, major research equipment, graduate laboratory facilities, institutional grants which the universities and colleges use for these purposes, and the science development programs. All of those programs have an impact on both research and science education, although not in every individual instance.

Finally, at the right is shown the science information programs. They also clearly have an impact on research and education, but in a more indirect way.

You can see here how our funds are divided for fiscal year 1965: \$170 million for out and out research programs, \$120 million for out and out educational programs, \$106 million for the institutional programs, and not quite \$12 million for the science information activities.

Mr. DADDARIO. I have a question, and we will probably run into this again later on, about your science education program for supplementary education of science teachers. In the event that a university had a science major that it might be able to convince to go into the educational field but who was not in fact a science teacher at the time, do you have the capability of providing funds for him under this program, or is there a hiatus there?

Dr. HAWORTH. I think I will let Dr. Riecken discuss that question. This is Dr. Henry Riecken, Associate Director for Education.

Dr. RIECKEN. Could a science major obtain support in studying science to become a teacher?

Mr. DADDARIO. Yes.

Dr. RIECKEN. As a graduate student, he would become eligible for——

Mr. DADDARIO. He would be eligible for the competitive fellowship programs, but my question is directed at this particular program. The question is should the program be enlarged?

Dr. HAWORTH. Let me try. I think I understand now.

This program, supplementary education of science teachers, is directed at teachers already in service. We have not been very active in the sort of thing you have been talking about—the preservice training of teachers—that is a field which we feel we must press forward on. We are doing a little experimenting there already.

The reason for our approach was this: There were thousands of science teachers already in service, already trained, many of them not well trained initially and many of them out of date because they had been out of college so long. As I understand it—this is, of course, well before my time in the Foundation—the reasoning was that the quickest return per dollar could be obtained by putting emphasis on upgrading this very large number that were already teaching. Although it would be nice to do everything at once, with limited resources, choices have to be made. But preservice training is one of the things that Dr. Riecken talks most about being anxious to do. There are experimental programs, but they are not very sizable.

Mr. DADDARIO. At any rate, you are giving thought to putting more money in this area, now that you have had some experience with these programs?

Dr. HAWORTH. Yes. One of the things on which I will say more later is that I believe that throughout our science education programs—except perhaps the fellowships and traineeships—that the Foundation should strive to find new methods, to make innovations, to lead the way. We would hope that not only will our programs have direct impact—as, for example, this supplementary training has had—but also that they will stimulate action by the local and State authorities.

We feel, too, that some of our experimental approaches will be helpful to the Office of Education in the sorts of things that it does, not only for science but for other fields. In other words, in one sense, we want to continue to do research and development on science education, to carry out experiments and find innovations. You have put your finger on one of the things that we feel is very important.

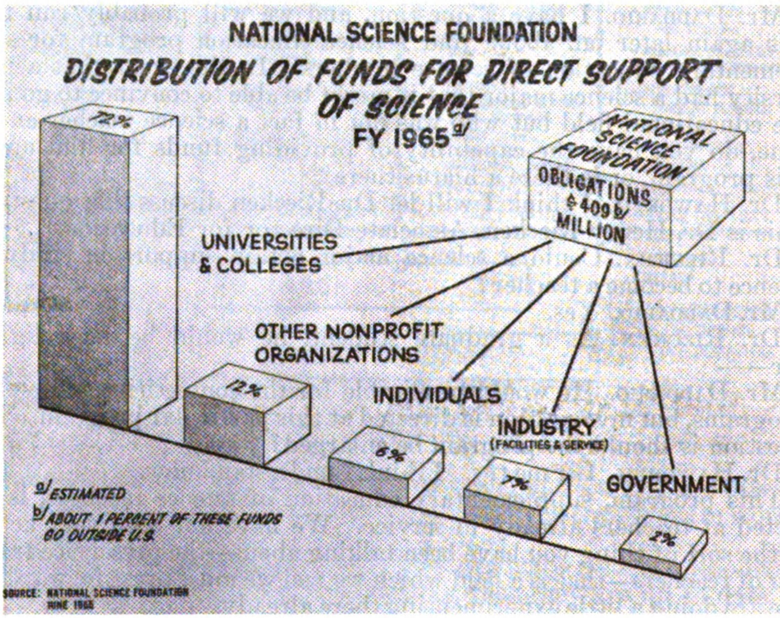


Chart 11

The next thing I would like to show is where our support money goes. These are the same funds that were included in chart 10; chart 11 shows where they go. Again, some of the categories are not sharply defined, as I will explain in a moment. I should say here that the percentages are those of 1964, but the dollar amount is that of 1965. We don't yet have the final breakdown on 1965, of course, but assume that 1965 will show about the same pattern.

Of $409 million of obligations in fiscal year 1965 for the actual support of research and education and information activities—and I am leaving out our own internal administrative cost, the policy planning studies, and things of that sort—72 percent goes to the colleges and universities, 12 percent to other nonprofit organizations, and 6 percent to individuals, meaning primarily for fellowships.

There are a very few cases of research grants to individuals, but they are trivial in number. Seven percent goes to industry, mainly for facilities and services, the largest item of that being for the design and construction of the Mohole equipment. We do not in general support research in industry, but occasionally we must buy things or have them made. Two percent is transferred to other agencies of the Government.

Mr. MILLER. Where does that 2 percent go?

Dr. HAWORTH. For example, in our antarctic program some funds go to the Weather Bureau and to the Office of Naval Research, to help carry out that program, which we totally fund. Another example is Dr. Herbert Friedman's rocket flights. You are fully aware of that program. We provide funds there to purchase rockets, and so forth, for university people who come in and work with Dr. Friedman. Although the work is for the benefit of the university scientists, the arrangement shows up as an intergovernmental transfer.

The bar indicating 6 percent to individuals is one I would like to say a bit more about; the sums involved represent our awards to individuals instead of to organizations. Thus all the Foundation's fellowship programs are included, and indeed constitute the bulk of the funds reported in this bar. The amount includes the educational allowances as well as the stipends to the fellows.

However, this bar does not include our support of graduate student awards under the traineeship heading, since we make grants in this program to universities, and they select the individuals who become trainees. The point I am emphasizing here is that the 6 percent shown for awards to "individuals" somewhat understates the overall situation; we actually devote a considerably larger sum to support of students at various levels. This situation is much the same as the problem of reporting on "prime contracts" versus "subcontracts." You let a big contract to a prime contractor to do some big job, and he immediately subcontracts a lot of it. It is exactly the same situation. So, my main point is that a substantial part of this goes to individuals in this kind of sense. I am not using the payroll sense, but the fellowship and traineeship sense.

Mr. MILLER. Doctor, you have a footnote here, "About 1 percent of these funds go outside the United States." I assume that is the total.

Dr. HAWORTH. Yes.

Mr. MILLER. Are we spending enough in this area?

Dr. HAWORTH. That is a good question. Incidentally, part of that 1 percent is actually going to support Americans. Some of it is going for the translations that I spoke of. There is some support for research activities by foreign institutions. For example, some support goes to the Naples Zoological Station, but mostly because Americans go there and work. However, we are not requiring that it be used to support Americans.

Mr. MILLER. There are European science facilities. I have always felt in the interest of science that we should take advantage of their work. I just wonder whether we have spent enough money in this field.

Dr. HAWORTH. Well, of course, there is a great deal of give and take with Western Europe. For example, one of the most interesting sides of my experience at Brookhaven was the interplay between the CERN Laboratory at Geneva and ourselves. We didn't finance each other in any sense, but we worked very closely together, and were the best of friends.

Mr. MILLER. But there are other areas.

Dr. HAWORTH. I think we should go all out in cooperating in this sense. To what extent we should finance research abroad depends on the circumstances, of course.

One thing is not indicated which is pertinent to this. The NSF does a considerable amount in the way of international science activities. For example, we have a participating agency service agreement with the AID whereby through a transfer of funds to the Foundation we are managing two science education improvement programs in Central and South America. Therefore, we are involved in international programs perhaps somewhat more than the line indicating appropriated funds would lead one to believe.

Mr. MILLER. I had the privilege of attending the dedication of the Air Force astronomical instrument at Arecibo, P.R. The American press were not present but the South American press, El Mundo, had about 10 people there. I have often wondered if this wouldn't be helpful in not only raising the standard of science in these countries, but also in establishing a closer working relationship.

Dr. HAWORTH. I personally feel that cooperation in science offers one of the few windows that show any real promise of solving some of our really important problems of the world. I have had a great deal of personal experience, for example, with Russian scientists. There are some Russian scientists who are very good friends of mine. The antarctic program is another good example. If we can gain a little bit of understanding here or there that can gradually grow, we can help greatly to change attitudes, I think. And that is fundamentally what has to happen.

Mr. MILLER. Last fall a group of this committee went to the Pacific to visit our tracking stations and other facilities, and we spent better than half a day in Manila with General Romulo in the University of the Philippines. As you know, he is trying to develop an Asian center there. He stated that the Asian people will accept that even quicker than anything else because of the relationship that we already have in this area. I thought this was a fine way to perhaps penetrate into this area that is so important to us but giving us so much trouble now, by supporting the work that they are doing, by bringing American educators there, and perhaps by bringing Philippine educators here. It is just like the American University in Beirut. It had a great influence in the Middle East. We ought to be looking for this sort of thing in the Far East. Of course, this is a lot further down the line than we are discussing now.

Dr. HAWORTH. There is a lot of things going on now. I think one of the rather promising activities is the sister relationship that has been established between certain American universities and foreign universities.

Mr. DADDARIO. Dr. Haworth, we will stop here for the day. This committee will adjourn until 10 o'clock tomorrow morning.

Mr. MILLER. Before we go, Mr. Chairman, I would like to express my appreciation to Dr. Haworth and his staff for the very fine presentation they have made.

(Whereupon, at 12:02 p. m., the meeting was adjourned to reconvene at 10 a. m., Thursday, June 24, 1965.)

NATIONAL SCIENCE FOUNDATION

THURSDAY, JUNE 24, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., the Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. The meeting will come to order.

Good morning, Dr. Haworth. Would you proceed, please.

FURTHER STATEMENT OF DR. LELAND J. HAWORTH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. Haworth. You will recall that when we stopped yesterday I had been discussing chart 11 (see p. 30). A point that I had not quite come to yet was that, in terms of support of individuals for other than services rendered, an important component that could go in the "individuals" box are the institutes where teachers are given individual stipends while participating in further training. Since they receive the stipends through the university or college conducting the institute, the funds actually show up in the universities and colleges box.

In other words, the direct or indirect support of individuals is really two or three times as great as the chart would indicate. I think with that I can go on to the next chart.

I might call attention to the fact that in your books chart 12 is followed by chart 12–A which breaks down the NSF research and education totals in detail. This is to give you a rough idea of how our funds are spent and how they relate to research and education in terms of the way we define these activities. Most of our research funds also bear on education, and many of our education funds bear on research, but this is the way we actually categorize them, according to primary purpose.

In chart 12, we show operational funds, that is, funds supporting actual activities, as distinguished from facilities funds for the purchase or construction of major equipment, buildings, and things of that sort. You will see that in terms of programs which one can classify cleanly, about three-quarters goes to operational funds and about 16 percent goes for facilities. The institutional grants and the science development funds are used for mixed purposes, and we simply do not have any way of subdividing them; that is, we do not have

NATIONAL SCIENCE FOUNDATION

SCIENCE PROGRAMS SUPPORT, FY 1965 a/

(Thousands of Dollars)

<table>
<tr><th>SUPPORT MECHANISM</th><th>OPERATIONAL FUNDS</th><th>FACILITIES b/</th><th>TOTAL</th></tr>
<tr><td>• RESEARCH</td><td>$170,323</td><td>$38,526</td><td>$208,850</td></tr>
<tr><td>• SCIENCE EDUCATION</td><td>120,684</td><td>–</td><td>120,684</td></tr>
<tr><td>• GRADUATE SCIENCE FACILITIES</td><td>–</td><td>28,000</td><td>28,000</td></tr>
<tr><td>• INSTITUTIONAL BASE GRANTS</td><td colspan="2">$11,404</td><td>11,404</td></tr>
<tr><td>• SCIENCE DEVELOPMENT</td><td colspan="2">$28,000</td><td>28,000</td></tr>
<tr><td>• SCIENCE INFORMATION SERVICES</td><td>$ 11,607</td><td>–</td><td>11,607</td></tr>
<tr><td>TOTAL</td><td>$302,614</td><td>$66,526</td><td rowspan="2">$408,545</td></tr>
<tr><td></td><td colspan="2">$39,404</td></tr>
</table>

NOTE: DETAIL MAY NOT ADD TO TOTAL BECAUSE OF ROUNDING

a/ ESTIMATED OBLIGATIONS

b/ INCLUDES MAJOR EQUIPMENT

SOURCE NATIONAL SCIENCE FOUNDATION JUNE 1965

CHART 12

Science Programs Support, FY 1965 1/
(thousands of dollars)

<table>
<tr><th>Support Mechanism</th><th>Operational Funds</th><th>Facilities 2/</th><th>Total</th></tr>
<tr><td>Research</td><td></td><td></td><td></td></tr>
<tr><td>Research project grants</td><td>$118,606</td><td>---</td><td>$118,606</td></tr>
<tr><td>Specialized research facilities</td><td>---</td><td>$28,786</td><td>28,786</td></tr>
<tr><td>National research programs</td><td>39,525</td><td>2,452</td><td>41,978</td></tr>
<tr><td>National research centers</td><td>12,192</td><td>7,288</td><td>19,480</td></tr>
<tr><td>Subtotal</td><td>170,323</td><td>38,526</td><td>208,850</td></tr>
<tr><td>Science Education</td><td></td><td></td><td></td></tr>
<tr><td>Fellowships and traineeships</td><td>40,200</td><td>---</td><td>40,200</td></tr>
<tr><td>Instructional equipment for undergraduate education</td><td>7,995</td><td>---</td><td>7,995</td></tr>
<tr><td>Institutes</td><td>43,250</td><td>---</td><td>43,250</td></tr>
<tr><td>Course content improvement</td><td>14,400</td><td>---</td><td>14,400</td></tr>
<tr><td>Other</td><td>14,839</td><td>---</td><td>14,839</td></tr>
<tr><td>Subtotal</td><td>120,684</td><td>---</td><td>120,684</td></tr>
<tr><td>Graduate science facilities</td><td>---</td><td>28,000</td><td>28,000</td></tr>
<tr><td>Institutional base grants</td><td colspan="2">$11,404</td><td>11,404</td></tr>
<tr><td>Science development</td><td colspan="2">28,000</td><td>28,000</td></tr>
<tr><td>Science information services</td><td>11,607</td><td>---</td><td>11,607</td></tr>
<tr><td>Total</td><td>$302,614</td><td>$66,526</td><td rowspan="2">$408,545</td></tr>
<tr><td></td><td colspan="2">$39,404</td></tr>
</table>

1/ Estimated obligations.

2/ Includes major equipment.

Note: Detail may not add to total because of rounding.

Source: National Science Foundation, June 1965.

CHART 12–A

statistics to show how much of the institutional base grant is actually used by a university to renovate a laboratory as distinguished from some operational function.

I would be glad to answer any questions, but I think an inspection of the chart gives a fair idea of the situation.

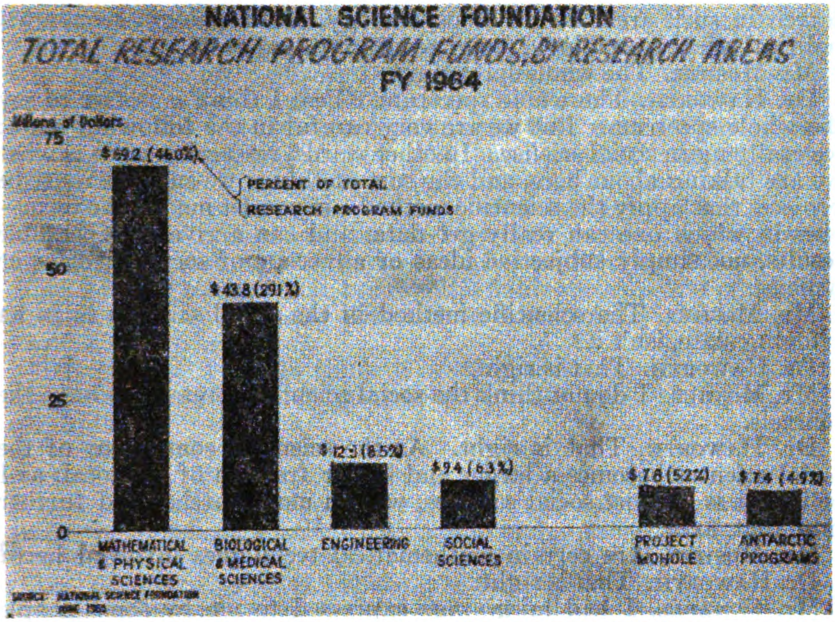


CHART 13

I turn now to chart 13. This shows the relative way in which we support various kinds of research activities in different fields. The first four blocks show the amounts of money granted in support of the various fields in fiscal year 1964, regardless of whether the funds came under the budget heading of research project grants or, say, under national programs, such as the International Indian Ocean Expedition, except for two special cases. We have pulled out Project Mohole and the Antarctic programs separately. The other national programs are included in the first four boxes.

You can see that most of the funds go to the mathematical and physical sciences, which, of course, include the earth sciences, the atmospheric sciences, astronomy, and so on. Again, unless you have questions I won't attempt to go into detail.

Relatively speaking I believe it is fair to say that the proportion of our total research support going to the social sciences has shown the most growth, with engineering close behind. As you know, we didn't start supporting social sciences as early as we did the others, and more attention has been given to the engineering sciences in recent times. For example, only about a year or a year and a half ago we separated engineering science organizationally from the physical sciences, and now it is a full-fledged division of the same stature as the mathematical and physical or the biological and medical sciences.

Mr. MOSHER. Could you give us an indication of where the emphasis lies in the social sciences? Is it psychology?

Dr. HAWORTH. Social psychology was the first one to be supported. Actually, there was not a sudden branching out to cover all the social sciences. Rather they have been included gradually. We support re-

search in such areas as social psychology, anthropology, economics, political science, sociology, social geography, and so on.

Mr. MOSHER. The whole spectrum?

Dr. HAWORTH. The whole spectrum. Yes; I think it is fair to say the whole spectrum. But we are very careful in the following sense: we really mean social science. In other words, research science is what we are talking about here, and the sort of things we support must be projects that apply the scientific method—if you let me use the term—ones in which one can really get data, and can arrive at repeatable results, not simply subjective ideas or advocacy of social theories or policies.

Mr. MOSHER. The scientific method in the social sciences is in an evolving state, isn't it?

Dr. HAWORTH. That is right.

Mr. MOSHER. I do not think the social scientists pretend to have the controls.

Dr. HAWORTH. That is right. As the scientific component of the social sciences becomes a larger and larger fraction of the total, as I believe it is in most social sciences, we can move further and further into that area.

Mr. MOSHER. Are certain mathematical techniques involved here?

Dr. HAWORTH. That is right.

Mr. CONABLE. I had misgivings expressed to me by some people about the establishment of the Humanities Foundation because of the impact it might have on the National Science Foundation's contributions to the social sciences. As you describe it, the two need not overlap at all.

Dr. HAWORTH. I think I would rather say there would be a fuzzy edge. You can say, "something over here we can do, and something over here we cannot do." Just where the break comes in between——

Mr. CONABLE. Even if the Humanities Foundation is established, this is not a reason for you to stop supporting social sciences?

Dr. HAWORTH. That is correct.

Mr. CONABLE. There are some people who feel that the National Science Foundations' contribution to the social sciences is important. They are concerned lest the National Science Foundation discontinue its support of the social sciences if the Humanities Foundation is established because this new foundation can take care of that function.

Dr. HAWORTH. We haven't any intention of doing that. Incidentally, we very much welcome the Humanities Foundation. I think it is badly needed. I think we can complement each other rather than rival each other.

Mr. CONABLE. It would impart a certain symmetry to the program.

Dr. HAWORTH. That is right.

Mr. BROWN. Dr. Haworth, we probably will get into a further exploration of this social science support later, but is there anything in your enabling statute, or is there any administrative restrictions with regard to the support that you give the social sciences or the proportion of your funds that go to the social sciences?

Dr. HAWORTH. Perhaps I can answer your question somewhat obliquely. At the time of the passage of the original National Science Foundation Act, there was lively debate—or discussion at least—as to whether the social sciences should be included, and then the question,

if they were included, how would one define them. This was finally resolved by including in the act a phrase saying that we should support the "mathematical, physical, medical, biological, engineering, and other sciences." It was left then to the Foundation, the executive branch and the Congress, to determine as time went on just what one could define as "other sciences." So, there is no restriction in the sense of any barrier. I guess that answers that part of your question.

So far as the relative support is concerned, this has been, it is fair to say, largely a matter determined by the Foundation itself within its budgetary limitations, and, as I have pointed out, social science came into the picture later because the fields were spelled out and the Foundation was virtually directed to do naturally the things that were picked up first.

Mr. BROWN. I would think it would be natural that those things which are specifically delineated or named would get the primary emphasis.

Dr. HAWORTH. Yes.

Mr. BROWN. With regard to the composition of the National Science Board, I presume that there is a similar emphasis upon representatives from the physical, mathematical, and biological sciences, and relatively small representation from the social sciences?

Dr. HAWORTH. Yes. I believe it is correct that on the Board there is a larger representation of the physical sciences than the social sciences. But the social sciences are well represented, not only because of the fact that we have the research responsibility in these fields but we have responsibility for education, and many of the leading educators come from the social sciences. For example, one board member is Dr. Katherine McBride, the president of Bryn Mawr. She is a psychologist—but she is a member just as much because she is a leading educator as because she is a scientist. That tends perhaps, as I said, to admix the membership a little more than if we supported only research.

Mr. BROWN. In other words, the Board has greater proportion of representation from the social sciences than would be reflected in NSF expenditures for the social sciences?

Dr. HAWORTH. I believe that is true. I haven't thought through all the members at the moment, but I believe that is correct.

Mr. BROWN. Do you have established criteria which you use as a basis for the allocation of your funds between the different branches? I am thinking here in terms of criteria that relate to the importance of the scientific field to the national welfare, or to some other standard that can be either generally or specifically spelled out?

Dr. HAWORTH. The criteria I must confess are rather general and vague. As you know and as I think most of the people who wrote papers for the recent Academy report to this committee said, there is no formula way in which you can decide these things.

One of the important criteria that we have used is simply what is the situation with respect to good research that is being proposed? If, at a given time, we find that we have to turn down relatively more good proposals in chemistry, let's say, than we have to turn down in physics, then we will tend to increase the support in chemistry. It is a little bit like driving a car, or perhaps more clearly like guiding the Explorer to Mars. It has a course, you let it follow it for a while, and

then you find it isn't going to quite the right place, so you put in a correction. The correction is largely based, or has been, on the kind of finding that I indicated. Subjective judgment is involved. It is not a calculable matter, deciding that we are neglecting some field compared with another.

Mr. MOSHER. When you use the words "good proposal," how do you define that? You said there are more good proposals in chemistry than in physics at any one time.

Dr. HAWORTH. No; I said "If we have to turn down a bigger proportion of the good ones." These are evaluated by our own staff and by our panels of advisers. The general picture is looked at by people like Dr. Randal Robertson, the Associate Director for Research and by our divisional committees which cover whole broad areas, not just a single subject. We are in the stage of flying by the seat of our pants, if you want to use that phrase, in this area of balance among fields of science at this time.

Mr. MOSHER. They are evaluated against what criteria?

Dr. HAWORTH. Against the criteria of the proven ability of the man or men proposing the project, against what seems to be, and this is always a little harder to evaluate, the value and potential productivity of the ideas and the proposed course of action. Project proposals are more or less specific on these matters. We certainly don't give funds simply to somebody who says, "I am going to do some research in physics" or "I want to do some research in nuclear physics."

Mr. MOSHER. Productivity of knowledge?

Dr. HAWORTH. Of knowledge.

Mr. CONABLE. It seems to be implicit in what you are saying that any good man with a worthy project is entitled to the support of the Federal Government. Is that a fair statement?

Dr. HAWORTH. I think I would say he is entitled to request support. There isn't enough support to go around to all the good men.

I think I should add one more thing. It is our belief—and this, of course, is subject to question—that the support of science could well be higher than it is. That is, there is good science that would be useful to the country that isn't being done, and so long as that is true, then I would accept what you just said. This is not to say that there won't come a time—there might—when the country will have a high enough level of science and there might be more scientists than we need. I don't foresee that, but it is not inconceivable.

Mr. BROWN. Doctor, I presume from what you have just said here that there is a substantially smaller volume of proposals made in the social sciences than there are in the physical sciences.

Dr. HAWORTH. That is correct.

Mr. BROWN. You are not, for example, funding 50 to 75 percent of the proposals in physics and only 5 or 10 percent in the social sciences?

Dr. HAWORTH. No; we are not. As a matter of fact, at the moment we are probably doing relatively a little better in supporting the proposals in the social sciences. Now, this varies from time to time, of course.

Mr. BROWN. I think we will explore some of these questions a little further, but I just wanted to get some of these points out on the table.

Mr. DAVIS. Would you please make a few comments about the expenditures that are made in the field of engineering? I notice that the field of engineering is 8½ percent of the total. What considerations enter into that sort of outlay?

Dr. HAWORTH. In the first place, we must recognize that the charter of the National Science Foundation does not allow us to cover all the fields of engineering. I don't mean that we cannot have some chemical engineering and some electrical engineering, but we cannot cover all kinds of activities in engineering. We are chartered and directed to pursue basic research. Now, at first sight one would say that would mean we cannot do anything in engineering because in a sense "basic research in engineering" is a contradiction in terms.

One of the things, though, that one must bear in mind is that there is a difference between saying "engineering research" and "research carried out by engineers." Just as there is many a physicist in a chemistry department who considers himself, by now, a chemist although he is doing research in physics, so many an engineer does basic research. Also, we have taken to some extent the view that what you mean by the term "basic research" depends on the circumstance. In the field of high energy physics there isn't any such thing as applied research at the moment. Maybe there will be in the future. So it is all basic research. But to some extent one can take the view—he has to be careful—that research that is basic to some scientific or technical area can be thought of as basic research. That is the view we have taken here. Research that is basic to general principles, to general advances in engineering, is what we define as basic research in engineering.

Mr. DAVIS. Let me think of a project. Suppose somebody were to train a computer how to design something; would you call that engineering?

Dr. HAWORTH. You mean the act of training it or developing it?

Mr. DAVIS. Developing it; yes.

Dr. HAWORTH. I will have to ask Dr. John Ide, Director of the Foundation's Division of Engineering.

Dr. IDE. I would say definitely yes.

Mr. BROWN. Let me give another example in the high energy physics field. Suppose you are concerned with new developments in a high energy accelerator; I am talking about the machine in which you produce the phenomenon which you wish to investigate. Is that engineering or is that physics?

Dr. HAWORTH. In terms of our ability to support it, we consider it definitely a part of the appropriate activities in basic research because it was designed and built to accomplish basic research. The act of building it, designing and building it, is actually a combination of physics and engineering.

Some very basic physics, for example, had to be done to be able to understand the motion of the beams, the particle beams, in the present so-called alternating gradient synchrotrons. For example, physicists combined with the engineers to build the big machine at Brookhaven. It is a tool for basic research and its cost is, therefore, a legitimate expense to be charged against basic research.

Mr. BROWN. Is it basic engineering research or basic physics research?

Dr. HAWORTH. In this case we would charge it to basic physics because the objective was basic physics.

For example, we are supporting the design and construction of an electron synchrotron at Cornell University; it will cost about $12 million. Actually, this column in chart 13 does not include facilities costs. But if we had a facilities cost in here, we would put that cost in the mathematical and physical sciences, not in engineering, even though a great deal of the activity is engineering.

Mr. DAVIS. I would imagine it is often hard to decide in what column to put an expenditure.

Dr. HAWORTH. It certainly is. Sometimes they belong in two or three columns. Much of this assignment is arbitrary.

Mr. MOSHER. Is isn't a very important question, is it?

Dr. HAWORTH. Not in this kind of sense.

Mr. MOSHER. I wouldn't think so. It is strictly for statistical purposes, isn't it?

Dr. HAWORTH. That's right. However, classification is important in terms of trends and things of that sort. The most important thing is to be consistent about classification from year to year.

Mr. MOSHER. As a tool for evaluating your policy?

Dr. HAWORTH. As a management tool, yes.

Mr. DADDARIO. It may be just a management tool from the statistics standpoint; however, you may not get the funds for the program if you put it down in your budget request as basic engineering, as Mr. Brown has pointed out, rather than basic research in physics. How you label it is unimportant after the fact, but it is extremely important as to whether you get the program going in the first instance.

Dr. HAWORTH. In the first place, you must be consistent. In the second place, everybody that uses the data must understand how it is made up, which would be essential to the point you make.

Chart 14 shows how the funds that are given out for basic research grants are distributed. Here we are leaving out the national centers and so on. These are the grants to individuals or small groups of individuals—or rather to the universities and colleges and other institutions to support the research of individuals, or groups of individuals. This chart shows how those funds are expended. Not quite two-thirds goes for salaries and wages. About 15 percent goes for permanent equipment. Major equipment is excluded; these are items which cost up to a few thousand dollars. Nine percent is for expendable equipment, supplies, and so forth; a very small amount is for travel and scattered other expenses.

Then, at the right in order not to clutter up the circle at the left too badly, we show the salary component separately. Salaries reimbursed for the principal investigators is about 13 percent of total direct costs. About half or perhaps a little more salaries for them is for summer work. In general, their academic appointments do not carry through the summer and they are given research appointments that we reimburse. The rest is the reimbursement for that part of the time that they spend on our research in the regular academic year. We are not covering all of that cost; that is, we are not reimbursing all of that cost.

Faculty associates account for 4 percent of the total; they are members of the faculty other than the principal investigator.

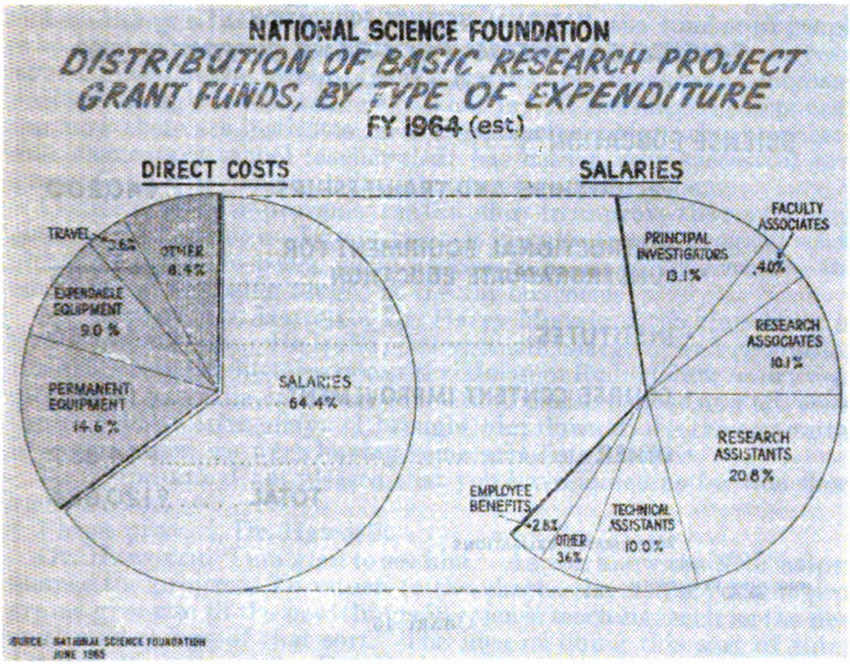


CHART 14

Ten percent is for salaries of research associates. These people work for 2 or 3 years after receiving their Ph. D.'s as an extension of their graduate education.

Twenty percent is for research assistants. Those are predominantly graduate students who help earn their way by employment as assistants on research projects, just as many graduate students help earn their way by part-time teaching.

Then, there are the technical assistants, 10 percent, other kinds of people, and employee benefits.

So you can see, as I said, that about two-thirds of direct costs goes for payroll in one form or another.

Let me now turn to chart 15, the Foundation's science education programs. I have been talking up to now about the types of research support. I will now talk about, science education—fellowships and traineeships, teacher training, course content improvement, research participation by teachers and undergraduates, and so on. Here is the breakdown for fiscal year 1965 of our allocations of funds that are specifically identified as science education, which total \$120 million. About a third goes for fellowships and traineeships; the preponderance of these go to graduate students.

This category also includes faculty fellowships, postdoctoral fellowships, and so on, but they comprise a small fraction of the total. The next category represents grants to colleges and universities, primarily to colleges, to buy instructional equipment for undergraduate instruction. It may be equipment for lectures or teaching laboratories or both. These grants run from a few thousand to several thousand

NATIONAL SCIENCE FOUNDATION

SCIENCE EDUCATION PROGRAMS SUPPORT, FY 1965 [a]

(Thousands of Dollars)

SCIENCE EDUCATION

- **FELLOWSHIPS AND TRAINEESHIPS** $40,200
- **INSTRUCTIONAL EQUIPMENT FOR UNDERGRADUATE EDUCATION** .... $ 7,995
- **INSTITUTES** $43,250
- **COURSE CONTENT IMPROVEMENT** .... $ 14,400
- **OTHER** .... $ 14,839

TOTAL $120,684

[a] ESTIMATED OBLIGATIONS

SOURCE: NATIONAL SCIENCE FOUNDATION
JUNE 1965

CHART 15

dollars—$10,000, $15,000. They are given, incidentally, on a 50–50 matching basis. The institution must provide the same amount that we do. These go, I believe, to between 500 and 600 colleges and universities each year. There are more grants than that, but in some instances there is more than one grant to a given institution.

The institutes I spoke of yesterday are of three kinds, as I said: First, there are the institutes conducted for teachers during their summer recess. They are of the order of 6 to 8 weeks long. The teachers try to get caught up on the material in the particular fields they teach. The institutes are conducted by colleges and universities that make proposals to us. The best are selected. Again we can fund only a fraction of the proposals.

The institution selects teachers—the institute trainees, if you want to call them that—from among persons who apply to the institute for admission. The institute is conducted in accordance with the college's plans. We fund the institute, and the institute pays nominal stipends to the teachers who have given up summer employment to go to these institutes.

Second, during the academic year there are so-called inservice institutes in which the teachers take similar training at night, on Saturdays, and other offduty hours, as an extracurricula activity. They are not given stipends because it is during a period when they are earning anyway.

Finally, there is a relatively small number of so-called academic year institutes, in which the teachers take a leave of absence from teaching duties for a school year to attend the institute and again, they are given a stipend because they are giving up earnings during this period.

I will show a little later, I believe, statistics on the number of people who have participated in these institutes. They started a dozen years ago, I guess, at the level of college teachers but quickly the emphasis shifted to high school teachers. That is still the largest component, but now there are institutes for college teachers, high school teachers, and elementary school teachers. It has been a very successful program, but I will come to relevant statistics in a moment.

Course content improvement is the effort to improve the content and general methodology—I don't mean it in quite the pedagogical sense, although there are pedagogical aspects to it—of the curriculum and courses that are being taught at the various levels.

Mr. MILLER. Dr. Haworth, Dr. Harry Messel, of the University of Sydney, is with me. He is the man who is in charge of and is building the Mills Cross radio telescope at the Molango Radio Observatory near Canberra, Australia, in connection with Cornell, to make new advances in the field of astronomy. I brought him down to see the committee in action when we were having some scientists testify.

Mr. DADDARIO. I am pleased that you have joined us for this short visit, Doctor.

Please proceed, Dr. Haworth.

Dr. HAWORTH. I am glad to see him. As you know the NSF helped finance the project. To return to the charts, the course content programs give rise to the new things in science teaching, such as the new math and things of that sort. The idea of doing this sort of thing did not originate in the Foundation; people like Max Beberman, at the University of Illinois, were already doing this before we got started in it. Nevertheless, it has been heavily supported and gives great momentum by the Foundation.

In particular, a technique that has been very successful in this—and one, I think, largely responsible for the great success—was developed in some of the projects supported by the Foundation. This technique, which several groups have used—one of the well known ones being PSSC, the physical sciences study committee that started originally at MIT under Dr. Zacharias—is to get together a group composed of leading research scientists plus science teachers at every level, plus school administrators, and meld together the different kinds of knowledge and information and ideas and experience that these groups of individuals have in order to produce a sensible, up-to-date, interesting, and inspiring course or curriculum. This is far more successful than to use either a physicist who is far away from high school kids and doesn't really know anything about handling them or what they can absorb, or a high school teacher who doesn't really know the up-to-date science. It is just like the situation in which both physicists and engineers are needed to build an accelerator. It takes several kinds of people to devise a curriculum. It isn't merely textbook writing. It is textbooks, plus laboratory equipment, plus increasing introduction of movie clips, plus background material for the teachers themselves that doesn't go to the students but helps the teacher to be a better teacher—the whole complex of things. This activity has been very successful. It is being actively carried out in physics, in biology, in chemistry, in math, and increasingly now in the earth sciences, and branching out into the social sciences, and so on. Again, it started at

the high school level. It has moved in both directions, into the college level and into the elementary school level.

One of the things that helped push along its introduction at the college level is that the youngsters who are coming out of the courses in high school that use these new materials and who study under retrained teachers just know too much for the old college textbooks. So, it has had a pushup effect.

Mr. DADDARIO. Do any of the other agencies, such as the Office of Education, also have programs in this field?

Dr. HAWORTH. Yes. As a matter of fact, we support a program or two jointly. They are tending to emphasize more the areas where we do not reach, but they are increasingly using this technique, and I think eventually, under various kinds of auspices, the Office of Education, the States, and so on, it will cover the whole area and the whole country.

Mr. DADDARIO. Are these programs being proposed with full knowledge of what the other agencies are doing? You do coordinate with the Office of Education, do you not? Do they know what the Foundation does, and do you know what they are doing?

Dr. HAWORTH. Yes; there is very close cooperation. It is especially close in this area.

Mr. DADDARIO. It is a program that is developing on a proper cooperative, rather than a competitive and duplicating basis?

Dr. HAWORTH. That's right. One thing I will be very careful to say is that we do nothing to promote the use of these materials whose development we have supported. That is, we put no pressures, no Madison Avenue salesmanship in the use of these. Rather we develop them, that is, the people whom we support develop them—I have to be careful about that, too—they become available, and, of course, it is up to the local authorities as to whether or not they use them.

Mr. DADDARIO. You mean you don't push at all in setting up a pilot program?

Dr. HAWORTH. We do in that sense, but that is part of the development process. What happens is an evolutionary process. One of these groups will get together and plan what they think is a reasonable course of action. A very common technique is to have a so-called summer writing session in which a substantial number of people get together and prepare materials. These are then published, not in hard cover books but in mimeographed form, and tried out in a number of schools, which use them voluntarily, of course. Then, as the result of that trial, usually of a year's duration, the materials are reworked and improved. Frequently materials go through more than one such phase, ultimately they are turned over by contract to a regular commercial publishing house which publishes for the open market.

The purpose of the remark that I wanted to be very careful to make was that we are not trying to influence the decision of the local and State school authorities with respect to the adoption of the materials.

Mr. DADDARIO. You make it available, and if it is good enough you expect——

Dr. HAWORTH. We expect it to sell itself. Incidentally, we are also careful, not to make any distinction in teachers institutes as to

whether or not they base their instruction on these materials. Some of them do, some of them don't. For example, in the summer teachers institutes. We are not biased. If the people are good and the planning is good but they don't propose to use the updated material, the last does not hurt their chances of getting a grant.

Mr. BROWN. We continue to increase the funds for science education through the NSF, and there has obviously been a dramatic increase following the sputnik in 1957. At the same time we continue a rapid increase in the funding of support for education through the Office of Education, and this has become quite rapid also in the past 3 or 4 years. As a result, it seems to me that we are going to have a continuing problem with regard to delineating the respective areas and determining functions which are appropriate. Is there some type of analysis being made toward the resolution of this problem?

Dr. HAWORTH. In the first place, let me say readily that it will require great care to do this. In the second place, let me say that there is quite close knowledge and cooperation between the two agencies. For example, Mr. Keppel head of the Office of Education, is a member of our advisory committee on science education. Dr. Riecken, our Associate Director for Education, is a member of some of the office and education advisory committees. And there are other cross links of this sort. In the third place, all up and down the staff level there is constant communication. We are doing this in an informed way.

Then, fourthly, let me say briefly what we believe our role in science education should be primarily. First the graduate level of science education, I think, is clearly one that predominantly should be the Science Foundation's responsibility. One of the important things that leads me to say all the things I am going to say is that the National Science Foundation is the agency of the Government that has the most intimate contact with the scientists themselves, especially in the universities: it knows where the good scientists are; it knows where good scientific work is being done. Now, at the other levels, and especially at the high school and elementary school levels, I believe that our role in science education should be one of leadership and innovation. Again, it is helpful that we know what places have good science departments that can really, for example, conduct a good institute, or what organizations are strong, or what people they propose to get together to make a curriculum study and so forth. The thing we should not do is to get into a massive across-the-board support of education, even science education, school district by school district. That is clearly at the other end. Then there is a whole range of things in between, and inevitably we may have some overlap. But I believe that sensible management in both agencies can make this combination a strength rather than a weakness, two agencies with somewhat different points of views.

Mr. BROWN. I feel this is true, but by the same token it may be true that sensible guidelines by Congress may be helpful in eliminating unnecessary proliferation.

Dr. HAWORTH. That may help also. Of course, the Federal programs in support of education through the Office of Education are growing so fast and are changing so fast that it is presently a little hard for me to really sort out and really see the full picture. Incidentally, when I say they are growing so fast, I am very strong for it.

Mr. CONABLE. Does the National Science Foundation have any interest or control over the end product of the course content improvement? You said you made it available after it has been thrashed out. Is this done between the researchers themselves and a regular commercial publishing house?

Dr. HAWORTH. That is right.

Mr. DADDARIO. The House is meeting today at 11 o'clock, Dr. Haworth, but I think we ought to continue until the first quorum call.

Dr. HAWORTH. A contract is made between the publisher and whatever organization carried out the curriculum development. It must be approved by the Foundation. The publisher pays a royalty to the grantee, and those royalty funds come back to the Treasury.

Mr. CONABLE. The money comes back to the Treasury?

Dr. HAWORTH. Yes.

Mr. CONABLE. So, you are reimbursed——

Dr. HAWORTH. Fractionally. Not the Science Foundation, but the Government. The royalties go into the general funds of the Treasury. What fraction of the original development cost will be repaid in that way over the long pull is hard to predict. It is now, of course, only a small fraction.

Included in the last line of chart 15 are a number of other programs. For example, the program for helping undergraduate students to participate in research at their own college or university is included. The funds are partly for the equipment and the supplies they use up. In some instances funds go for stipends for the promising student in financial need, or in the summer, when a student might be giving up employment by doing research. This gives good students a chance to do research and see what a science career is all about, as well as to learn. I think it is a very good thing.

Mr. MOSHER. Mr. Chairman, at some point are we going to get into a discussion of how the institutions are paid for overhead costs? What formula or limits are used?

Mr. DADDARIO. I had not expected that we would, Mr. Mosher, because we covered that subject in our hearings a year ago.

Mr. MOSHER. I think a progress report would be interesting at some point in these hearings because it still is a matter of controversy among the institutions.

Dr. HAWORTH. I am not very well informed as to what their attitudes have been since the action on the bill for health, education, and welfare, which covered NIH, and the independent offices bill, which covered us, which followed your advice.

Mr. MOSHER. When did that come up?

Dr. HAWORTH. At least our bill has only passed the House.

Mr. MOSHER. It isn't effective yet.

Mr. DADDARIO. I feel that we should wait and see how the revised Circular A-21 works out. We are kind of at the fulcrum point on this.

It appears that the Senate will go along on this, and we will have an opportunity to judge it throughout all the Government agencies. The circular does not affect just the National Science Foundation, but all agencies dealing with research. We ought to know in the next year how it works.

Mr. MOSHER. I agree.

Dr. HAWORTH. I will just mention one or two more things here.

Mr. DADDARIO. Could you finish up in a few minutes, Dr. Haworth, because the bells have just rang for the first call.

Dr. HAWORTH. Here in the last item on chart 15, are some experiments in setting up relationships between colleges and high schools to improve the high school teaching situation, and between colleges and universities to improve the teaching situation in the colleges. For example, in the State of Nebraska the university brings in teachers from the colleges and they spend a year at the university at the expense of the college. We help by reimbursing the college for that because they have to hire someone else to fill in for that year. The people go back to their colleges a lot more knowledgeable and better college teachers than they were when they left. Also, we are supporting a few projects for the preservice training of teachers.

NATIONAL SCIENCE FOUNDATION

FUNDS DIRECTED PRIMARILY TOWARD SUPPORT OF SCIENCE EDUCATION

FY 1952-64

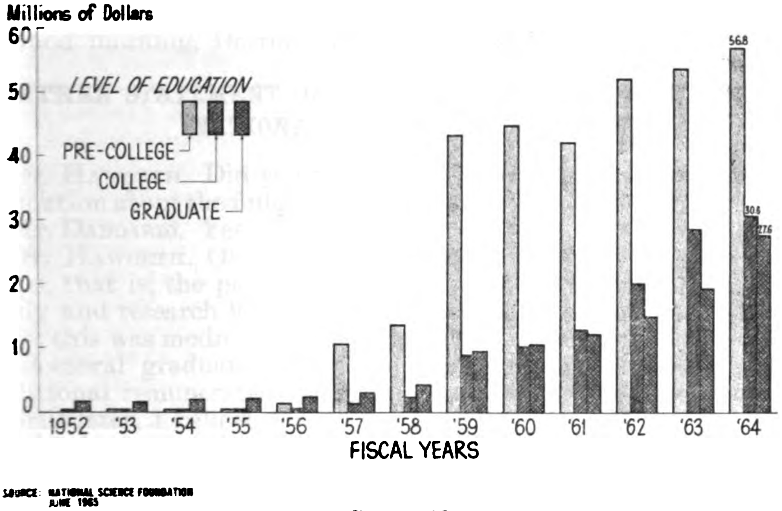


CHART 16

I think that on chart 16 this is fairly self-evident. You can see that, as was said, there has been a considerable growth since sputnik, although it took place fairly rapidly and has somewhat leveled off since with respect to the precollege sorts of things. On the other hand, at the college level there has been a little more of an increase in the last 3 or 4 years. This is partly because we have moved on in these two programs (indicating chart 15) from the high school to the college level.

At the graduate level this step-up between 1963 and 1964 indicates the result of the study for the President's Science Advisory Committee, by a panel of that committee chaired by Dr. Gilliland; it recommended very strongly that there be more support for graduate students in the physical sciences and engineering with emphasis on engineering. We put in our traineeship program in 1964; it is largely responsible for the step-up between 1963 and 1964 in the bar for the graduate level.

Mr. DADDARIO. Dr. Haworth, I would like to finish with a question which we could take up tomorrow morning. The emphasis which you have laid to the improvement of teaching and to the importance of this calls to my mind the problem in the academic community, concerning the limitation on fellowships so far as their teaching loads are concerned. Would you make some comment on that tomorrow morning?

This committee will adjourn until tomorrow morning at 10 o'clock. It has not been my original intention to meet Fridays, but I would like to meet tomorrow so that Dr. Haworth can finish his presentation. I would appreciate it if you can be available, Dr. Haworth.

Dr. HAWORTH. Oh, yes.

Mr. DADDARIO. Fine. Thank you.

(Whereupon, at 11:05 a.m., the meeting was adjourned to reconvene at 10 a.m., Friday, June 25, 1965.)

NATIONAL SCIENCE FOUNDATION

FRIDAY, JUNE 25, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee), presiding.

Mr. DADDARIO. The meeting will come to order.

Good morning, Doctor. Please start where we left off yesterday.

FURTHER STATEMENT OF DR. LELAND J. HAWORTH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. HAWORTH. Did you wish me to respond to your request for information about the fellowship program?

Mr. DADDARIO. Yes.

Dr. HAWORTH. Originally, the fellowships were full-time fellowships, that is, the people were expected to devote their full time to study and research leading to their degree. Very early, I believe in 1955, this was modified to allow the fellow—I am now talking about a predoctoral graduate fellow—to engage in some teaching without additional remuneration by arrangement with the Foundation.

Still later, I believe for the academic year 1961–62, it was further modified to allow the university to pay from its own funds an additional stipend for a reasonable amount of teaching. At the present time this supplement may be up to a thousand dollars per year. Now, this is done, of course, for two closely related reasons. First, it is clearly worthwhile in the training of students to have them engage in some teaching, and second, and perhaps more importantly, it is, to the benefit of the country that these people get some teaching experience during their formative graduate years. So the two predoctoral fellowship programs—the graduate and the cooperative graduate programs and the traineeship program, have this permissive arrangement.

Now, a small number of the fellows engaged in teaching even before they were allowed to receive additional remuneration. Of course, the number increased when they were permitted to receive some pay for teaching. The last year for which statistics were taken, about 33 percent of the regular graduate fellowship holders did engage in some teaching and the numbers for the cooperative graduate program were comparable. We did not then have the traineeship program, but there is no particular reason to believe it would be any different.

Now, this permissive supplementation of a thousand dollars per year by the institution should be put in perspective. The stipend level for the first year fellow is $2,400 and $500 is allowed for each dependent. If he is in his terminal year it is $2,800 plus dependent allowances. To this, a fellow or trainee may add up to $1,000 by teaching.

Mr. DADDARIO. Do you limit the extra stipend to a thousand dollars because that seems to be the figure——

Dr. HAWORTH. That seems to be a reasonable figure. Obviously, we don't want the fellows to do nothing but teach; they are, after all, fellows in order to go to school. That seems to be a reasonable figure in terms of the amount of teaching that would be appropriate.

Mr. DADDARIO. That would cover the time that he would be able to add to his fellowship?

Dr. HAWORTH. That is essentially the idea.

Mr. DADDARIO. When you say that the figure jumped to 33 percent, Dr. Haworth, what did it jump from?

Dr. HAWORTH. It was around, as I recall, 12 or 13 percent, before any supplementation was permitted, and then when the universities were permitted to pay, it jumped up I believe the first year to 25 percent and then the next year to 33 percent.

Mr. DADDARIO. Is 33 percent a good figure? How do you judge it? Should there be more of these men and women participating?

Dr. HAWORTH. Personally, I would like to see more. The decision is, of course, made by the fellowship holder himself, and the university. In some instances the university and perhaps the professor that he is studying under do not want him to teach. But those are decisions made locally, by the professor, the university, and the fellow.

Mr. DADDARIO. Then part of the stimulation has come from the change to allow the $1,000 addition?

Dr. HAWORTH. Yes, sir.

Mr. DADDARIO. The rest of it, then, would involve university action, wouldn't it?

Dr. HAWORTH. Yes. One thing we should bear in mind, of course, is that this doesn't mean that only 33 percent of the fellows do some teaching at one time or other, because many of them hold fellowships for 2 and 3 and occasionally even 4 years, and this is just how much teaching was done during a given year.

Mr. DADDARIO. Yes, but it would be during that period——

Dr. HAWORTH. I mean that some of the other 67 percent who did not teach in 1962–63 might have taught in 1963–64. So far as the count of individuals is concerned, it is almost inevitable it would be more than that, during sometime in their fellowship.

Mr. DADDARIO. I see that, but these are people who are extremely talented. You would expect they would have a great impact on the students if they did carry a teaching load.

Dr. HAWORTH. Yes. That is right.

Mr. DADDARIO. It might be more helpful at that time rather than a later or earlier time. There might be greater continuity to it. This is obviously something to which you have given attention, and there has been additional teaching carried out. I have asked the question because I have had an opportunity to discuss this with some of the academic people. They are concerned, and do feel, as you have said,

that the universities could apply some more thought to it to see if this percentage figure could be raised.

Dr. HAWORTH. This has been, as you imply, given a great deal of attention over the years by the staff, by the National Science Board, in careful consultation with the university deans and faculties.

Mr. DADDARIO. When you say the $1,000 additional stipend did activate the teaching to this extent, is the limit on the figure an inhibiting factor, too? Should that be raised?

Dr. HAWORTH. I am afraid I couldn't answer that question. Dr. Fontaine, who is in charge of the fellowship program, might wish to comment.

Dr. FONTAINE. Mr. Chairman, we endeavor to keep in touch with schools on this matter through what we call a "coordinating official" at each Ph. D.-granting institution in the United States. Through a series of meetings held in April, for example, it was rather clear that within this $1,000 supplementation framework the institutions felt that they could take care of the majority of the cases where the individuals wished to teach and the institutions wished to supplement the stipend. Perhaps I should point out that we do not require the institution to supplement the fellow's or trainee's stipend.

Mr. DADDARIO. I understand that.

Dr. FONTAINE. But if they do wish to supplement, and I would say—based on the opinions expressed by these people that I referred to as "coordinating officials," usually graduate deans—that they still feel this is an appropriate amount. We have adjusted it from an earlier base—a lower base—to the $1,000. So, it has not always been $1,000. We have tried to keep this in mind.

Mr. DADDARIO. It would be helpful if we could have for the record information on how this was adjusted from one figure to the other over the course of the program. Could we have that data?

Mr. HAWORTH. Yes.

(The information requested is as follows:)

CHANGES IN AMOUNT OF SUPPLEMENTATION FOR TEACHING

Graduate fellowships.—Prior to the academic year 1961–62, a fellow's stipend could not be supplemented by his institution for teaching. In 1961–62, the Foundation, after approval by the National Science Board, allowed the fellowship institution to supplement the fellow's stipend by an amount not to exceed $600 per annum.

The $600 teaching for pay permissibility was continued through the 1963–64 fellowship year. Following a further study of the problem and after conferring with the graduate deans of all institutions granting the Ph. D. degree in the sciences in the United States, the Foundation in the 1964–65 fellowship year increased the permissible supplementation to $1,000 per annum. In 1964–65, the same supplementation amount ($1,000) was permitted in the graduate and cooperative graduate fellowship programs and in the graduate traineeship program, and it is at this same level for all three programs in 1965–66.

Dr. HAWORTH. I should like to emphasize a point that Dr. Fontaine made. We don't require that they give a supplement, nor do we require that it be a thousand dollars; but it cannot exceed $1,000 per year.

Chart 16 (see p. 47) shows the growth of support for science education broken down into a different set of categories, that is, broken down according to whether it primarily affects precollege education, undergraduate, or graduate education. In the first box, of course,

are those things that relate, say, to high school teacher training or supplementary training because the eventual impact that we are after, of course, is at the precollege level. So with respect to the secondary teacher institutes, for example, although the instruction is at the college level, the eventual hoped-for impact is on students at the precollege level.

You can see how these have grown. I believe I talked, as a matter of fact, a bit about this yesterday.

NATIONAL SCIENCE FOUNDATION

SUPPORT OF INDIVIDUALS UNDER SELECTED SCIENCE EDUCATION PROGRAMS

PROGRAMS	CUMULATIVE NUMBER OF STIPENDS PROVIDED [a]	NUMBER OF PARTICIPANTS (FY 65)
GRADUATE FELLOWSHIPS & TRAINEESHIPS	34,300	6,800
POST-DOCTORAL FELLOWSHIPS	3,100	400
PROGRAMS FOR COLLEGE TEACHERS	27,500	4,700
PROGRAMS FOR COLLEGE STUDENTS	37,000	6,200
PROGRAMS FOR SECONDARY SCHOOL TEACHERS	253,300	37,100
PROGRAMS FOR SECONDARY SCHOOL STUDENTS	58,200	9,800
INSTITUTES FOR ELEMENTARY SCHOOL TEACHERS	15,600	4,600

[a] PROGRAMS INITIATED FY 1951-64, TOTALS ESTIMATED

SOURCE: NATIONAL SCIENCE FOUNDATION
JUNE 1965

CHART 17

Next, chart 17, is an attempt to give an impression about how many individuals have been affected by the various education programs, that is, affected directly through their own participation.

Clearly in the training of teachers the real impact that we are after is ultimately on the students of those teachers and we have no way of counting the number of students so affected. If we look first at the last column which shows the annual rate this year of the support of various fellowship holders and teachers and so forth, there are 6,800 predoctoral fellowships and traineeships, 400 postdoctoral fellowships, for 4,700 college teachers in programs of one sort or another including the summer institutes and things of that sort. Also included are science faculty fellowships for college teachers who take a year's leave of absence and go to a university to continue their study. Included also are programs for undergraduate students (including an undergraduate research participation program); programs for secondary school teachers (the bulk of this being the institutes about which we have already spoken); and programs for secondary school students, where we give them a chance to take part in some science activity in the summertime. The latter are primarily projects in which

the students attend courses given in the summer by college and universities, rather than in high schools. Typically, the courses are not advanced high school courses, but are very special studies the students would not otherwise be able to undertake. Finally, included are institutes for elementary school teachers. As you see, all this is relatively new.

In the first column we try to give an indication of the cumulative effect over the years. For example, 34,300 is the number of graduate fellowships and traineeships that have been given. The data do not represent, however, the number of different individuals, because many individuals hold fellowships or traineeships for more than 1 year. We don't have at hand statistics on the number of different individuals. That is, this very impressive number down here, 253,300 grants of stipends to secondary school teachers, does not represent 253,300 different teachers—although clearly the latter is also a large number—because while many of them attend only one institute, some attend two or three. There is a limit on summer institute attendance, however; now teachers may not receive stipends in summer institutes for more than 32 weeks all told. This is not because we wouldn't like to be able to support an individual teacher for more than 32 weeks but, within the limits of available funds we want to spread the support among many teachers needing help.

As you can see, there has been a sizable number of secondary school teachers affected by this program. You can also see that participation has been growing at an increasing rate because the number in the last year is around 15 percent of the cumulative total for something like 13 years. In the next 2 years we will double that.

Mr. DADDARIO. How do you expect the program for the elementary school teachers to develop over the course of time? As you say, it is a relatively new one. What is its prospect for the future?

Dr. HAWORTH. It is growing. I don't recall how much difference there is between this year and last.

Dr. RIECKEN. It has been a gradual increase. I will give you the number for the record.

National Science Foundation institutes for elementary school personnel—Program history

Fiscal year	Proposals received	Amount requested	Stipends requested	Institutes granted	Amount granted	Stipends granted	Actual attendance
1959	90	$2,585,207	3,572	23	$550,900	855	893
1960	127	4,124,640	6,147	28	590,090	950	1,004
1961	196	5,478,926	7,379	54	857,630	1,664	1,812
1962	166	3,428,545	6,807	56	912,765	1,772	2,083
1963	199	4,222,644	8,144	79	1,358,560	2,449	2,788
1964	289	6,384,946	11,112	107	1,735,419	3,354	3,639
1965	305	6,886,812	12,915	101	1,738,900	4,541	[1] (4,600)
Total	1,372	33,091,720	56,076	448	7,750,264	15,585	[1] (16,819)

[1] Estimate.

Dr. HAWORTH. There is, of course, a tremendous number of elementary school teachers, more than a million. Because of their great numbers, we realize that we can't hope to reach them all directly. So we have made a special effort to reach the key teachers—the leaders—in the hope that each such teacher will attend one or more institutes and, after returning home, will inspire and help the others.

Special attention has been paid to that in this program for elementary school teachers.

Mr. MOSHER. And special attention to teachers in science?

Dr. HAWORTH. This is all for teachers of sciences or mathematics or, in the case of college, engineering also.

Mr. CONABLE. Does this represent a very new program, or does it represent a new interest in science in the elementary schools, or does it represent both?

Dr. HAWORTH. It is both. I don't recall when this started.

Dr. RIECKEN. In 1959 we started helping elementary school teachers.

Mr. CONABLE. But it has meant a shifting of the curriculum to include more science instruction in the elementary schools?

Dr. HAWORTH. Yes. The important thing to note is that mathematics is included here and represents the bulk of the program. There is getting to be more, and feeling among educators, of course, especially among scientists who are interested in education, that science education in the lower grades should have an increased importance, not only for its own sake, but also because the study of science is a way to get the student to begin to appreciate the importance of logic and proof—of understanding the rules of evidence in a nonlegal sense. The student of science learns to base his conclusions on facts. Science teaches him a way of thinking logically as well as simply conveying some facts to him.

We believe that something like half of the high school teachers of science and mathematics have now been reached by these programs, but many inadequately.

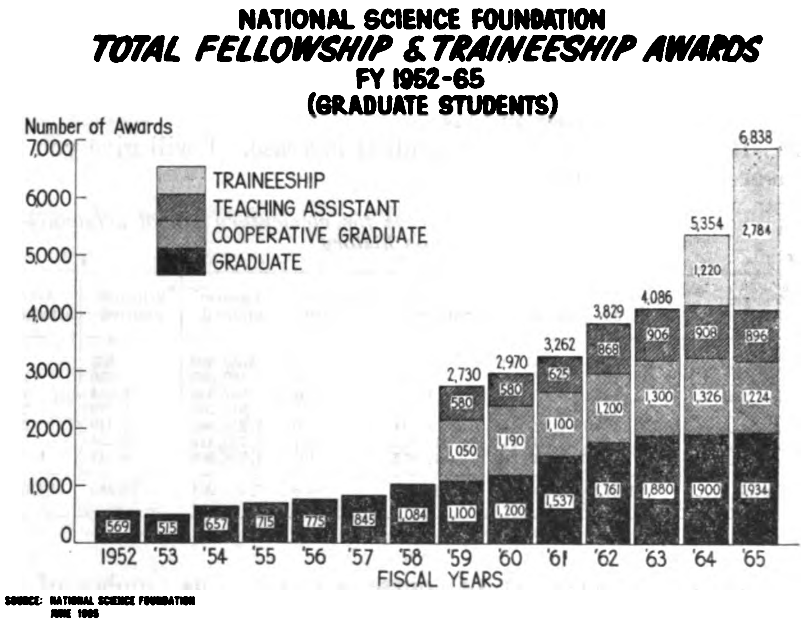


CHART 18

Chart 18 shows the growth of the fellowships, breaking them down a little further now by the various fellowship and traineeship awards for predoctoral graduate students. You can see that new programs have been added from time to time, the original program being what we now call the regular graduate fellowship program. It is the one that is based on a straight national competition in which individuals make applications, compete nationally, and are judged by central panels of scientists, and the best selected.

This is the program I was speaking of the day before yesterday, when we were talking about the geographic distribution of fellowships. Incidentally, I should correct one thing I said at that time. I said that had the 10-percent limitation been in effect this year, we could not have given any fellowships to residents of New York State in quality group 2. Actually, we did not, even without a limitation. Even so, 15 percent of our fellowships were given to people who declared themselves to be residents of New York State. So that with a 10-percent ceiling we would have to eliminate some New York residents in quality group 1 next year.

Mr. DADDARIO. As I understood your comment, you indicated it was not a good thing to have this residence limitation because it would affect your ability to support the highest quality people.

Dr. HAWORTH. Yes. Mr. Chairman, I am in favor of having good universities and colleges in all parts of the country, all regions of the country; I am also in favor of giving opportunity to every individual to develop himself as far as he can. But I think in the national interest we must have some programs, be they for research or for fellowships, that must be administered purely on the quality basis. We must keep them separate; we must not fuzz up the quality programs by other considerations such as geography. Let's achieve such goals with programs that are designed to develop better institutions.

Mr. CONABLE. Didn't I understand that your major point also was that the residence of the student was no reasonable criterion since these people went to college almost everywhere?

Dr. HAWORTH. That is part of it. The country mustn't lose the usefulness, the maximum usefulness of the very best people and the very best institutions.

Mr. MOSHER. Have we discussed whether the individual need and the economic need are factors in your selection?

Dr. HAWORTH. The individual need and the economic need are not factors.

Now, as to this other point that I was making—some of these successive steps have been involved in that, but in a little different sense. By the act, and I think appropriately, the fellowship holders are allowed to attend the university of their choice. The university does not have to accept them, but they are free to attend whatever university they prefer, provided they are accepted by that university. That means that graduate fellows tend to concentrate in a relatively few institutions. They all want to go to the best universities, of course.

In recognition of that tendency, the cooperative graduate fellowship program was instituted in 1959. The mechanism there is that individuals apply through the university that they wish to attend. The university then endorses them and comments on them, and so forth,

and the application is made. They are judged individually essentially, but then, of course, the awardees attend whatever universities they applied through. The result, therefore, as far as this group is concerned, is a much wider distribution of fellows among the universities than in the case of the "regular" graduate fellowship program.

If I can skip the teaching assistant program for a moment, I would like to turn to the traineeships. The traineeships were instituted in 1964 as a result of the studies of the Gilliland Panel of the President's Science Advisory Committee, in which there was concern about our ability to educate as many postgraduates, and particularly Ph. D.'s as possible, with the feeling that the country will need an increasing number. It was difficult to decide how many, but the Panel finally said, even though the ratio of students who would like to go into graduate school and get a Ph. D. in physics, engineering, or whatever, it might be, stayed constant, the growth in the number of students will be such that there had to be an increase of the sort that I spoke of the day before yesterday, in another connection. This will require an increasing amount of support, the Panel said, and, furthermore, there is unused capacity, in many graduate universities, for science and engineers, although some were perhaps overcrowded. So in response to that report we set up the traineeship programs in which the university itself applies, department by department, for traineeships, stating how many they think they can use, that is, how many students they can accommodate. These applications, then, are evaluated here in Washington not in terms of individual students but in terms of the judged quality of the department, the estimate of unused capacity, how much they could expand and still keep their quality up, and so on. And then we make grants for a specified number of traineeships to the university and the university selects the trainees.

This is why we call the individuals trainees as distinguished from fellows, who are selected by the Foundation in a national competition, although the general purpose, of course, is the same in both cases.

Mr. Conable. Doctor, to what extent do you decide how many trainees each college will get? They say what they think they can handle, is that it?

Dr. Haworth. In giving them the grant, we give them so much money for a specified number of traineeships and it is never as much as they ask for. In the first year we gave traineeships only in engineering. In the second year we gave them in engineering, the physical sciences, and mathematics, and we hope in 1966 or 1967, depending on funds available and so forth, to expand the program to include biology and the social sciences. The Gilliland report stressed the physical sciences and engineering, and especially stressed the need for more engineering support. Although we had hoped to start the traineeship program in all those fields, the first year our funds were not sufficient, and we decided, instead of scattering traineeships thinly across many fields, to concentrate on one field—engineering.

Mr. Brown. Can I ask at this point if you could provide just a little bit more detail in connection with these data as to the breakdown in the various fields that are covered—that is, physics, math, and so

forth—and the approximate ratio of the number that you are supporting as to the total number.

Dr. HAWORTH. Would you like for us to do it now or put it in the record?

Mr. BROWN. Either way.

Mr. DADDARIO. You may submit it later.

(The information requested is as follows:)

It is estimated that approximately 18,000 full-time graduate students in science, mathematics, and engineering will be supported in 1965 through the principal Federal predoctoral fellowship and traineeship programs administered by the Atomic Energy Commission, National Aeronautics and Space Administration, National Science Foundation, Office of Education, and the Public Health Service. Of this number, approximately one-third will be supported by the National Science Foundation.

National Science Foundation predoctoral fellowship and traineeship awards offered by program and field, fiscal year 1965

Field	Total	Graduate fellowships	Cooperative graduate fellowships	Graduate traineeships
Engineering (E)	2,206	273	296	[1] 1,637
Mathematics (M)	825	386	236	203
Physical sciences (P)	1,625	643	440	542
Any EMP fields	402			[2] 402
Subtotal	5,058	1,302	972	2,784
Life and medical sciences	453	343	110	([3])
Social sciences and psychology	431	289	142	([3])
Subtotal	884	632	252	
Total	5,942	1,934	1,224	2,784

[1] Of the 1,637 estimated awards in engineering, 712 were new traineeships and 925 "continuation" traineeships. A continuation traineeship is defined as a traineeship awarded in a previous year (fiscal year 1964 in this instance) under a grant to an institution and supported for another year from the current fiscal year (1965) funds. Although the institution may exercise some discretion in assigning continuation traineeships to fields being supported in the current program, it is the Foundation's expectation that the institution will normally continue the award in the same field in which the original grant was made.

[2] Of the 402 traineeships awarded to institutions in "any" EMP fields, it is anticipated that some will be assigned to engineering and others to the mathematical and physical sciences.

[3] In fiscal year 1964 traineeships were awarded in engineering only, and in fiscal year 1965 in engineering, mathematical, and physical sciences. In fiscal year 1966 the Foundation will make traineeship awards in the life, medical, and social sciences and psychology for the first time.

Mr. DADDARIO. The traineeship program would seem to both build up the quality of the school and to train people whom you might not otherwise have an opportunity to even know about?

Dr. HAWORTH. That is right. To give you an idea of the impact, we gave grants in 1964 to 109 universities—that is, graduate engineering institutions, and that represented nearly all the ones in the United States that give Ph. D. degrees. That is a criterion for eligibility, that they give Ph. D. degrees. This year, 163 institutions received grants, the same ones, and additional ones. This gets to be a pretty big fraction of the institutions that give Ph. D. degrees in science.

Mr. DADDARIO. It seems to me it would help the record if we could get a list of them.

Dr. HAWORTH. We can give you a list showing the breakdown of where all these people go.

(The information requested is as follows:)

NATIONAL SCIENCE FOUNDATION

Graduate Traineeships[1/] in the Engineering, Mathematical, and Physical Sciences

Fiscal Year 1965

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
ALABAMA					
AUBURN UNIVERSITY AUBURN ALA	W V PARKER DEAN, GRADUATE SCHOOL	4	20.712	4	23.319
UNIVERSITY OF ALABAMA UNIVERSITY ALA	ERIC RODGERS DEAN, GRADUATE SCHOOL	4	20.712	3	20.140
		8	$41,424	7	$43,459
ALASKA					
UNIVERSITY OF ALASKA COLLEGE ALASKA	K M RAE VICE-PRESIDENT, RESEARCH AND ADVANCED STUDY	2	10.356		
		2	$10,356		
ARIZONA					
ARIZONA STATE UNIVERSITY TEMPE ARIZ	W J BURKE VICE PRESIDENT	10	51.780	5	30.802
UNIVERSITY OF ARIZONA TUCSON ARIZ	HERBERT D RHODES DEAN, GRADUATE COLLEGE	21	108.738	9	53.986
		31	$160,518	14	$84,788
ARKANSAS					
UNIV OF ARKANSAS FAYETTEVILLE ARK	VIRGIL W ADKISSON DEAN, GRADUATE SCHOOL	4	20.712	2	12.506
		4	$20,712	2	$12,506
CALIFORNIA					
CALIF INST OF TECHNOLOGY PASADENA CALIF	F BOHNENBLUST DEAN, GRADUATE STUDIES	37	191.586	19	113.040
STANFORD UNIVERSITY PALO ALTO CALIF	ROBERT M ROSENZWEIG ASSOCIATE DEAN, GRADUATE DIVISION	57	295.146	36	215.042
UNIV OF CALIFORNIA BERKELEY CALIF	SANFORD S ELBERG DEAN, GRADUATE DIVISION	47	243.366	37	212.844
UNIV OF CALIFORNIA DAVIS CALIF	BYRON R HOUSTON DEAN, GRADUATE DIVISION	11	56.958	3	15.804
UNIV OF CALIFORNIA LOS ANGELES CALIF	CARL M YORK ASSOCIATE DEAN, GRADUATE DIVISION	27	139.806	6	34.858
UNIV OF CALIFORNIA RIVERSIDE CALIF	RALPH B MARCH DEAN, GRADUATE DIVISION	7	36.246		
UNIV OF CALIF-SAN DIEGO LA JOLLA CALIF	NORRIS W RAKESTRAW DEAN, GRADUATE DIVISION	15	77.670		
UNIV OF CALIFORNIA SANTA BARBARA CALIF	EARL LESLIE GRIGGS DEAN, GRADUATE DIVISION	6	31.068		

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
UNIV OF THE PACIFIC STOCKTON CALIF	WILLIS POTTER DEAN, GRADUATE SCHOOL	2	10,356		
UNIV OF SANTA CLARA SANTA CLARA CALIF	ROBERT J PARDEN DEAN, SCHOOL OF ENGINEERING			2	11,471
UNIV OF SOUTHERN CALIF LOS ANGELES CALIF	MILTON C KLOETZEL DEAN, GRADUATE SCHOOL	15	77,670	11	61,626
		224	$1,159,872	114	$664,685
COLORADO					
COLORADO SCHOOL OF MINES GOLDEN COLO	A R JORDAN DEAN, GRADUATE SCHOOL	2	10,356	4	24,939
COLORADO STATE UNIV FORT COLLINS COLO	W H BRAGONIER DEAN, GRADUATE SCHOOL	6	31,068	6	36,658
UNIVERSITY OF COLORADO BOULDER COLO	JEREMIAH M ALLEN ACTING DEAN, GRADUATE SCHOOL	20	103,560	11	61,783
UNIVERSITY OF DENVER DENVER COLO	DAVID A DAY DEAN, COLLEGE OF ENGINEERING	3	15,534	2	11,381
		31	$160,518	23	$134,761
CONNECTICUT					
UNIV OF CONNECTICUT STORRS CONN	N L WHETTEN DEAN, GRADUATE SCHOOL	5	25,890	4	23,072
WESLEYAN UNIVERSITY MIDDLETOWN CONN	ROBERT A ROSENBAUM DEAN OF SCIENCES	4	20,712		
YALE UNIVERSITY NEW HAVEN CONN	ELGA R WASSERMAN ASSISTANT DEAN GRADUATE SCHOOL	26	134,628	7	38,779
		35	$181,230	11	$61,851
DELAWARE					
UNIVERSITY OF DELAWARE NEWARK DEL	C E BIRCHENALL DEAN, GRADUATE SCHOOL	11	56,958	7	40,129
		11	$56,958	7	$40,129
DISTRICT OF COLUMBIA					
CATHOLIC UNIVERSITY WASHINGTON D C	JAMES P OCONNOR DEAN, GRADUATE SCHOOL OF ARTS & SCIENCES	8	41,424	3	15,460
GEORGE WASHINGTON UNIV WASHINGTON D C	ARTHUR E BURNS DEAN, GRADUATE COUNCIL	3	15,534	2	12,371
GEORGETOWN UNIVERSITY WASHINGTON D C	JAMES B HORIGAN, S.J. DEAN, GRADUATE SCHOOL	5	25,890		
HOWARD UNIVERSITY WASHINGTON D C	CARROLL L MILLER ACTING DEAN, GRADUATE SCHOOL	3	15,534		
		19	$98,382	5	$27,831

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
FLORIDA					
FLORIDA STATE UNIVERSITY, TALLAHASSEE FLA	THOMAS R LEWIS ASSOC DEAN, GRADUATE SCHOOL	15	77,670		
UNIVERSITY OF FLORIDA GAINESVILLE FLA	L E GRINTER DEAN, GRADUATE SCHOOL	16	82,848	8	49,412
UNIVERSITY OF MIAMI CORAL GABLES FLA	ARMIN H GROPP DEAN, GRADUATE SCHOOL	9	46,602		
		40	$207,120	8	$49,412
GEORGIA					
EMORY UNIVERSITY ATLANTA GA	CHARLES T LESTER DEAN, GRADUATE SCHOOL OF ARTS & SCIENCES	4	20,712		
GEORGIA INST OF TECHNOL ATLANTA GA	M J GOGLIA DEAN, GRADUATE DIVISION	22	113,916	14	83,482
UNIVERSITY OF GEORGIA ATHENS GA	GERALD B HUFF DEAN, GRADUATE SCHOOL	5	25,890		
		31	$160,518	14	$83,482
HAWAII					
UNIVERSITY OF HAWAII HONOLULU HAWAII	WYTZE GORTER DEAN, GRADUATE SCHOOL	4	20,712		
		4	$20,712		
IDAHO					
UNIVERSITY OF IDAHO MOSCOW IDAHO	L C CADY DEAN, GRADUATE SCHOOL	4	20,712	2	12,838
		4	$20,712	2	$12,838
ILLINOIS					
ILLINOIS INST OF TECHNOL CHICAGO ILL	ARTHUR GRAD DEAN, GRADUATE SCHOOL	16	82,848	8	44,192
LOYOLA UNIVERSITY CHICAGO ILL	STEWART E DOLLARD, S.J. DEAN, GRADUATE SCHOOL	2	10,356		
NORTHWESTERN UNIVERSITY EVANSTON ILL	ROBERT H BAKER DEAN, GRADUATE SCHOOL	35	181,230	21	119,426
SOUTHERN ILLINOIS UNIV CARBONDALE ILL	DAVID T KENNEY ACTING DEAN, GRADUATE SCHOOL	3	15,534		
UNIVERSITY OF CHICAGO CHICAGO ILL	HAROLD R VOORHEES COORDINATOR	19	98,382		
UNIVERSITY OF ILLINOIS URBANA ILL	MARVIN FRANKEL ASSOCIATE DEAN, GRADUATE COLLEGE	44	227,832	42	242,745
		119	$616,182	71	$406,363

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
INDIANA					
INDIANA UNIVERSITY BLOOMINGTON IND	JOHN W ASHTON DEAN, GRADUATE SCHOOL	19	98,382		
PURDUE UNIVERSITY LAFAYETTE IND	F N ANDREWS DEAN, GRADUATE SCHOOL	33	170,874	37	220,741
UNIV OF NOTRE DAME NOTRE DAME IND	PAUL E BEICHNER, C.S.C. DEAN, GRADUATE SCHOOL	14	72,492	8	47,612
		66	$341,748	45	$268,353
IOWA					
IOWA STATE UNIVERSITY AMES IOWA	J B PAGE DEAN, GRADUATE COLLEGE	16	82,848	10	58,559
UNIVERSITY OF IOWA IOWA CITY IOWA	ORVILLE A HITCHCOCK ACTING DEAN, GRADUATE COLLEGE	9	46,602	5	32,258
		25	$129,450	15	$90,817
KANSAS					
KANSAS STATE UNIVERSITY MANHATTAN KANSAS	WILLIAM L STAMEY ACTING DEAN, GRADUATE SCHOOL	9	46,602	4	25,389
UNIVERSITY OF KANSAS LAWRENCE KANSAS	WILLIAM J ARGERSINGER JR ASSOCIATE DEAN OF FACULTIES	13	67,314	6	35,173
		22	$113,916	10	$60,562
KENTUCKY					
UNIVERSITY OF KENTUCKY LEXINGTON KY	A D KIRWAN DEAN, GRADUATE SCHOOL	8	41,424	2	12,371
UNIVERSITY OF LOUISVILLE LOUISVILLE KY	RICHARD H WILEY CHAIRMAN DEPT OF CHEMISTRY	4	20,712		
		12	$62,136	2	$12,371
LOUISIANA					
LOUISIANA STATE U BATON ROUGE LA	MAX GOODRICH DEAN, GRADUATE SCHOOL	12	62,136	5	33,592
LOUISIANA STATE U NEW ORLEANS LA	DONALD G DAVIS ASSISTANT DEAN, ACADEMIC AFFAIRS	2	10,356		
TULANE UNIVERSITY NEW ORLEANS LA	JOHN L SNELL DEAN, GRADUATE SCHOOL	9	46,602	2	11,269
		23	$119,094	7	$44,861

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
MAINE					
UNIVERSITY OF MAINE ORONO MAINE	FRANKLIN P EGGERT DEAN, GRADUATE STUDY	3	15,534	2	13,721
Total		3	$15,534	2	$13,721
MARYLAND					
JOHNS HOPKINS UNIVERSITY BALTIMORE MD	ROBERT L STRIDER ASSISTANT DEAN	18	93,204	9	51,218
UNIVERSITY OF MARYLAND COLLEGE PARK MD	RONALD BAMFORD DEAN, GRADUATE SCHOOL	16	82,848	5	27,488
Total		34	$176,052	14	$78,706
MASSACHUSETTS					
BOSTON UNIVERSITY BOSTON MASS	RICHARD S BEAR DEAN, GRADUATE SCHOOL	3	15,534		
BRANDEIS UNIVERSITY WALTHAM MASS	HAROLD WEISBERG DEAN, GRADUATE SCHOOL OF ARTS & SCIENCES	12	62,136		
CLARK UNIVERSITY WORCESTER MASS	DWIGHT E LEE DEAN, GRADUATE SCHOOL &	4	20,712		
HARVARD UNIVERSITY CAMBRIDGE MASS	THOMAS K SISSON ASSISTANT DEAN GRADUATE SCHOOL	19	98,382	11	61,266
LOWELL TECHNOLOGIC INST LOWELL MASS	DOMINICK A SAMA DIRECTOR, GRADUATE SCHOOL	2	10,356		
MASS. INST OF TECHNOLOGY CAMBRIDGE MASS	HAROLD L HAZEN DEAN, GRADUATE SCHOOL	55	284,790	59	340,842
NORTHEASTERN UNIVERSITY BOSTON MASS	ARTHUR A VERNON DEAN, GRADUATE DIVISION	5	25,890	2	11,831
TUFTS UNIVERSITY MEDFORD MASS	PAUL H FLINT DEAN, GRADUATE SCHOOL OF ARTS & SCIENCES	4	20,712	3	17,800
UNIV OF MASSACHUSETTS AMHERST MASS	EDWARD C MOORE DEAN, GRADUATE SCHOOL	11	56,958	4	26,829
WORCESTER POLYTEC INST WORCESTER MASS	RICHARD F MORTON ASSOCIATE DEAN, FACULTY	4	20,712	2	10,835
Total		119	$616,182	81	$469,403
MICHIGAN					
MICHIGAN STATE U EAST LANSING MICH	KENNETH G STONE ASSISTANT DEAN, ADVANCED GRADUATE STUDIES	25	129,450	11	67,318
MICHIGAN TECHNOL UNIV HOUGHTON MICH	DONALD G YERG DIRECTOR, GRADUATE STUDIES	3	15,534	3	19,240
UNIVERSITY OF MICHIGAN ANN ARBOR MICH	FREEMAN D MILLER ASSOCIATE DEAN GRADUATE SCHOOL	52	269,256	38	215,511

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
WAYNE STATE UNIVERSITY DETROIT MICH	JOSEPH E HILL ASSOCIATE DEAN, GRADUATE DIVISION	7	36,246	2	12,371
		87	$450,486	54	$314,440
MINNESOTA					
UNIV OF MINNESOTA MINNEAPOLIS MINN	BRYCE CRAWFORD JR DEAN, GRADUATE SCHOOL	32	165,696	24	133,334
		32	$165,696	24	$133,334
MISSISSIPPI					
MISSISSIPPI STATE UNIV STATE COLLEGE MISS	J C MCKEE JR DEAN, GRADUATE SCHOOL	3	15,534	2	12,838
UNIV OF MISSISSIPPI UNIVERSITY MISS	LEWIS NOBLES DEAN, GRADUATE SCHOOL	4	20,712		
		7	$36,246	2	$12,838
MISSOURI					
ST LOUIS UNIVERSITY ST LOUIS MO	HAROLD HOWE DEAN, GRADUATE SCHOOL	2	10,356		
UNIVERSITY OF MISSOURI COLUMBIA MO	HENRY E BENT DEAN, GRADUATE SCHOOL	13	67,314	11	64,798
U OF MISSOURI AT ROLLA, ROLLA MO	WOUTER BOSCH DIRECTOR, GRADUATE SCHOOL	4	20,712		
WASHINGTON UNIVERSITY ST LOUIS MO	R A DAMMKOEHLER ASSISTANT PROVOST	15	77,670	6	32,720
		34	$176,052	17	$97,518
MONTANA					
MONTANA STATE COLLEGE BOZEMAN MONT	LOUIS DS SMITH GRADUATE DEAN	6	31,068	4	25,389
MONTANA STATE UNIVERSITY MISSOULA MONT	FRED S HONKALA DEAN, GRADUATE SCHOOL	2	10,356		
		8	$41,424	4	$25,389
NEBRASKA					
UNIVERSITY OF NEBRASKA LINCOLN NEBR	MERK HOBSON DEAN, GRADUATE SCHOOL	7	36,246	2	13,760
		7	$36,246	2	$13,760
NEVADA					
UNIVERSITY OF NEVADA RENO NEVADA	T D OBRIEN DEAN, GRADUATE SCHOOL	3	15,534	2	10,498
		3	$15,534	2	$10,498

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
NEW HAMPSHIRE					
DARTMOUTH COLLEGE HANOVER N H	JAMES F HORNIG ASSOCIATE DEAN OF FACULTY	8	41,424	2	10,819
UNIV OF NEW HAMPSHIRE DURHAM N H	EUGENE S MILLS DEAN, GRADUATE SCHOOL	4	20,712		
		12	$62,136	2	$10,819
NEW JERSEY					
NEWARK COL / ENGINEERING NEWARK N J	ALEX BEDROSIAN ASSISTANT DEAN, ADMINISTRATION	2	10,356		
PRINCETON UNIVERSITY PRINCETON N J	RUSSELL A FRASER ASSOCIATE DEAN, GRADUATE SCHOOL	27	139,806	14	84,022
RUTGERS U NEW BRUNSWICK N J	RICHARD SCHLATTER PROVOST	14	72,492	5	26,633
SETON HALL UNIVERSITY SOUTH ORANGE N J	JOSEPH G CONNOR DEAN, GRADUATE DIVISION	2	10,356		
STEVENS INST OF TECHNOL HOBOKEN N J	RALPH A MORGEN DEAN, GRADUATE STUDIES	9	46,602	5	28,208
		54	$279,612	24	$138,863
NEW MEXICO					
NEW MEXICO STATE UNIV UNIVERSITY PARK N MEX	EARL WALDEN DEAN, GRADUATE SCHOOL	4	20,712	5	30,593
UNIVERSITY OF NEW MEXICO ALBUQUERQUE N MEX	HAROLD L WALKER DIRECTOR, RESEARCH SERVICES	5	25,890	5	30,802
		9	$46,602	10	$61,395
NEW YORK					
ADELPHI UNIVERSITY GARDEN CITY L I N Y	MARY MCGRILLIES DIRECTOR, GRADUATE DIVISION	2	10,356		
ALFRED UNIVERSITY ALFRED N Y	J F MCMAHON DEAN, COL OF CERAMICS	3	15,534	2	13,271
CITY U OF N Y NEW YORK N Y	CLAUDE E HAWLEY ASSOCIATE DEAN, GRADUATE STUDIES	14	72,492	2	11,021
CLARKSON C OF TECHNOLOGY POTSDAM N Y	H L SHULMAN DEAN, GRADUATE SCHOOL	8	41,424	4	22,509
COLUMBIA UNIVERSITY NEW YORK N Y	RALPH S HALFORD DEAN, GRADUATE FACULTIES	29	150,162	15	77,886
CORNELL UNIVERSITY ITHACA N Y	FREDERICK S ERDMAN ASSOCIATE DEAN, GRADUATE SCHOOL	36	186,408	24	134,797
FORDHAM UNIVERSITY NEW YORK N Y	JOSEPH F MULLIGAN, S.J. DEAN, GRADUATE SCHOOL	2	10,356		

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
NEW YORK UNIVERSITY NEW YORK N Y	JOHN L LANDGRAF ACTING ASSISTANT DEAN, GRADUATE SCHOOL OF ARTS AND SCIENCES	30	155,340	8	42,977
POLYTEC INST OF BROOKLYN BROOKLYN N Y	ANTHONY B GIORDANO DEAN, GRADUATE SCHOOL	22	113,916	11	62,892
RENSSELAER POLYTEC INST TROY N Y	H P CATLIN CHAIRMAN, COMMITTEE ON GRADUATE FELLOWSHIPS	14	72,492	11	65,255
THE ROCKEFELLER INST NEW YORK N Y	FRANK BRINK JR DEAN, GRADUATE STUDIES	3	15,534		
STATE U OF NY AT BUFFALO BUFFALO N Y	RAYMOND EWELL VICE-PRESIDENT, RESEARCH	12	62,136	4	25,142
STATE U OF NY-C/FORESTRY AT SYRACUSE UNIVERSITY SYRACUSE N Y	SVEND O HEIBERG ASSOCIATE DEAN, GRADUATE STUDIES	3	15,534	3	16,990
STATE U OF NY-STONYBROOK STONY BROOK L I N Y	DAVID FOX ACTING DEAN GRADUATE SCHOOL	5	25,890	3	16,990
SYRACUSE UNIVERSITY SYRACUSE N Y	WILLIAM C WHEADON DIRECTOR, DIVISION OF SPONSORED PROGRAMS	18	93,204	8	46,166
UNIVERSITY OF ROCHESTER ROCHESTER N Y	S D S SPRAGG DEAN, UNIVERSITY COUNCIL ON GRADUATE STUDIES	16	82,848	8	47,268
YESHIVA UNIVERSITY NEW YORK N Y	IRVING JACOBS COMPTROLLER	7	36,246		
		224	$1,159,872	103	$583,164
NORTH CAROLINA					
DUKE UNIVERSITY DURHAM N C	R L PREDMORE DEAN, GRADUATE SCHOOL OF ARTS & SCIENCES	9	46,602		
N C STATE OF UNIV OF N C RALEIGH N C	WALTER J PETERSON DEAN, GRADUATE SCHOOL	20	103,560	11	63,898
UNIV OF NORTH CAROLINA CHAPEL HILL N C	C HUGH HOLMAN DEAN, GRADUATE SCHOOL	7	36,246	3	13,480
WAKE FOREST COLLEGE WINSTON-SALEM N C	HENRY S STROUPE DIRECTOR, DIVISION OF GRADUATE STUDIES	4	20,712		
		40	$207,120	14	$77,378

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
NORTH DAKOTA					
NORTH DAKOTA STATE UNIV FARGO N DAK	GLENN S SMITH DEAN, GRADUATE SCHOOL	2	10.356		
UNIV OF NORTH DAKOTA GRAND FORKS N DAK	CHRISTOPHER J HAMRE DEAN, GRADUATE SCHOOL	2	10.356		
		4	$20,712		
OHIO					
CASE INST OF TECHNOLOGY CLEVELAND OHIO	LOUIS GORDON DEAN, GRADUATE STUDIES	24	124.272	13	84.190
KENT STATE UNIVERSITY KENT OHIO	MARTIN K NURMI DEAN, GRADUATE SCHOOL	2	10.356		
OHIO STATE UNIVERSITY COLUMBUS OHIO	GEORGE R ST PIERRE ASSOCIATE DEAN GRADUATE SCHOOL	18	93.204	12	71.471
OHIO UNIVERSITY ATHENS OHIO	D K CLIPPINGER DEAN, GRADUATE COLLEGE	3	15.534		
UNIVERSITY OF CINCINNATI CINCINNATI OHIO	CAMPBELL CROCKETT DEAN, GRADUATE SCHOOL	7	36.246	3	16.990
WESTERN RESERVE UNIV CLEVELAND OHIO	LESTER G CROCKER DEAN, GRADUATE SCHOOL	10	51.780		
		64	$331,392	28	$172,651
OKLAHOMA					
OKLAHOMA STATE UNIV STILLWATER OKLA	JAMES H BOGGS DEAN, GRADUATE SCHOOL	4	20.712	8	46.239
UNIVERSITY OF OKLAHOMA NORMAN OKLA	ARTHUR H DOERR DEAN, GRADUATE COLLEGE	10	51.780	6	37.828
		14	$72,492	14	$84,067
OREGON					
OREGON STATE UNIVERSITY CORVALLIS OREGON	H P HANSEN DEAN, GRADUATE SCHOOL	9	46.602	4	25.389
UNIVERSITY OF OREGON EUGENE OREGON	NORMAN D SUNDBERG ACTING DEAN, GRADUATE SCHOOL	7	36.246		
		16	$82,848	4	$25,389
PENNSYLVANIA					
BRYN MAWR COLLEGE BRYN MAWR PA	ELEANOR A BLISS DEAN, GRADUATE SCHOOL	3	15.534		
CARNEGIE INST OF TECHNOL PITTSBURGH PA	CHARLES LAW MCCABE DEAN, GRADUATE STUDIES	26	134.628	15	84.254
DUQUESNE UNIVERSITY PITTSBURGH PA	J GERALD WALSH, C.S.SP. DEAN, GRADUATE SCHOOL	1	5.178		
LEHIGH UNIVERSITY BETHLEHEM PA	ROBERT D STOUT DEAN, GRADUATE SCHOOL	9	46.602	6	38.665

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
PENNSYLVANIA STATE UNIV UNIVERSITY PARK PA	E B VANORMER ASSISTANT DEAN, GRADUATE SCHOOL	30	155,340	10	56,309
TEMPLE UNIVERSITY PHILADELPHIA PA	GEORGE H HUGANIR DEAN, GRADUATE SCHOOL	3	15,534		
UNIV OF PENNSYLVANIA PHILADELPHIA PA	W M PROTHEROE VICE-DEAN, GRADUATE SCHOOL OF ARTS&SCIENCES	30	155,340	14	78,211
UNIVERSITY OF PITTSBURGH PITTSBURGH PA	RICHARD H MCCOY COORDINATOR	11	56,958	5	29,108
		113	$585,114	50	$286,542
RHODE ISLAND					
BROWN UNIVERSITY PROVIDENCE R I	R B LINDSAY DEAN, GRADUATE SCHOOL	16	82,848	5	28,208
UNIV OF RHODE ISLAND KINGSTON R I	PHILIP S VERY ASSISTANT DEAN, GRADUATE SCHOOL	3	15,534	3	16,450
		19	$98,382	8	$44,658
SOUTH CAROLINA					
CLEMSON UNIVERSITY CLEMSON S C	HUGH MACAULAY DEAN, GRADUATE SCHOOL	5	25,890	3	19,240
UNIV OF SOUTH CAROLINA COLUMBIA S C	R H WIENEFELD DEAN, GRADUATE SCHOOL	3	15,534	2	13,721
		8	$41,424	5	$32,961
SOUTH DAKOTA					
SOUTH DAKOTA STATE UNIV BROOKINGS S DAK	OSCAR E OLSON DEAN, GRADUATE SCHOOL	3	15,534		
UNIV OF SOUTH DAKOTA VERMILLION S DAK	WAYNE W GUTZMAN DEAN, GRADUATE SCHOOL	2	10,356		
		5	$25,890		
TENNESSEE					
U OF TENNESSEE KNOXVILLE TENN	HILTON A SMITH DEAN, GRADUATE SCHOOL	15	77,670	3	17,440
VANDERBILT UNIVERSITY NASHVILLE TENN	LEONARD B BEACH DEAN, GRADUATE SCHOOL	11	56,958	3	17,890
		26	$134,628	6	$35,330
TEXAS					
BAYLOR UNIVERSITY WACO TEXAS	J D BRAGG DEAN, GRADUATE SCHOOL	2	10,356		
NORTH TEXAS STATE UNIV DENTON TEXAS	ROBERT B TOULOUSE DEAN, GRADUATE SCHOOL	3	15,534		
RICE UNIVERSITY HOUSTON TEXAS	G H RICHTER DEAN, GRADUATE STUDIES	19	98,382	8	47,882

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
SOUTHERN METHODIST UNIV DALLAS TEXAS	CLAUDE C ALBRITTON JR DEAN, GRADUATE SCHOOL	3	15,534	3	19,690
TEXAS A AND M UNIVERSITY COLLEGE STATION TEXAS	WAYNE C HALL DEAN, GRADUATE STUDIES	9	46,602	4	26,289
TEXAS CHRISTIAN UNIV FORT WORTH TEXAS	J M MOUDY EXECUTIVE VICE CHANCELLOR	2	10,356		
TEXAS TECHNOLOGICAL COLL LUBBOCK TEXAS	FRED D RIGBY DEAN, GRADUATE SCHOOL	4	20,712	2	11,488
UNIVERSITY OF HOUSTON HOUSTON TEXAS	R BALFOUR DANIELS DEAN, GRADUATE SCHOOL	3	15,534	2	14,621
UNIVERSITY OF TEXAS AUSTIN TEXAS	LEO HUGHES ASSOCIATE DEAN, GRADUATE SCHOOL	28	144,984	15	94,064
		73	$377,994	34	$214,034
UTAH					
BRIGHAM YOUNG UNIVERSITY PROVO UTAH	WESLEY P LLOYD DEAN, GRADUATE SCHOOL	5	25,890		
UNIVERSITY OF UTAH SALT LAKE CITY UTAH	CARL J CHRISTENSEN COORDINATOR, COOPERATIVE RESEARCH	13	67,314	8	55,818
UTAH STATE U LOGAN UTAH	J STEWART WILLIAMS DEAN, SCHOOL OF GRADUATE STUDIES	7	36,246	4	26,694
		25	$129,450	12	$82,512
VERMONT					
UNIVERSITY OF VERMONT BURLINGTON VT	WILLIAM H MACMILLAN DEAN, GRADUATE SCHOOL	2	10,356		
		2	$10,356		
VIRGINIA					
COLL OF WILLIAM AND MARY WILLIAMSBURG VA	ROBERT T SIEGEL DEAN, GRADUATE STUDIES	2	10,356		
UNIVERSITY OF VIRGINIA CHARLOTTESVILLE VA	FRANK L HEREFORD DEAN, GRADUATE SCHOOL OF ARTS AND SCIENCES	9	46,602	5	28,208
VIRGINIA POLYTEC INST BLACKSBURG VA	WARREN W BRANDT VICE PRESIDENT AND GRADUATE DEAN	7	36,246	8	47,178
		18	$93,204	13	$75,386

STATE AND INSTITUTION	COORDINATING OFFICIAL	NEW TRAINEESHIPS No.	NEW TRAINEESHIPS $Amount	CONTINUATION TRAINEESHIPS No.	CONTINUATION TRAINEESHIPS $Amount
WASHINGTON					
UNIVERSITY OF WASHINGTON SEATTLE WASH	EDWARD L ULLMAN ASSOCIATE DEAN, GRADUATE SCHOOL	30	155,340	15	101,624
WASHINGTON STATE UNIV PULLMAN WASH	J F SHORT DEAN, GRADUATE SCHOOL	6	31,068	3	14,830
		36	$186,408	18	116,454
WEST VIRGINIA					
WEST VIRGINIA UNIVERSITY MORGANTOWN W VA	J F GOLAY DEAN, GRADUATE SCHOOL	5	25,890	2	11,488
		5	$25,890	2	$11,488
WISCONSIN					
MARQUETTE UNIVERSITY MILWAUKEE WISC	L W FRIEDRICH, S.J. DEAN, GRADUATE SCHOOL	5	25,890		
UNIV OF WISCONSIN MADISON WISC	ROBERT A ALBERTY DEAN, GRADUATE SCHOOL	37	191,586	17	100,832
		42	$217,476	17	$100,832
WYOMING					
UNIVERSITY OF WYOMING LARAMIE WYO	ROBERT H BRUCE DEAN, GRADUATE SCHOOL	5	25,890	2	12,388
		5	$25,890	2	$12,388
	Totals	1859	$9,625,902	925	$5,434,987

1/ In fiscal year 1964, the first year of the Traineeship Program, awards were made in engineering only to 109 institutions; in fiscal year 1965 awards were made in the engineering, mathematical, and physical sciences to 163 institutions. Of the 2,784 traineeships awarded in fiscal year 1965, 1,859 were for new and 925 for "continuation" traineeships. A "continuation" traineeship is defined as a traineeship awarded in a previous year (fiscal year 1964 in this instance) under a grant to an institution and supported for another year from the current fiscal year (1965) funds.

Dr. HAWORTH. The graduate teaching assistant fellowships are awarded for study and research in the summer to students who are part-time teachers in the academic year. They receive stipends for only the summer months.

Chart 19 (p. 70) gives an idea of how many institutions we are reaching in all our programs. The total of 914 is not the sum of the numbers participating in individual programs because many institutions receive funds in more than one category. This total of 914 institutions is out of a little more than 1,000 universities and colleges granting some kind of a degree in science or engineering.

Chart 20 (p. 71) gives an idea of how our research support funds are distributed among the nine geographic divisions. Funds for facilities are omitted because when only 1 or 2 years are being considered, the inclusion of facilities data creates a distortion since a particular facilities grant may be large compared with the total for the year.

Here, as you can see, the left-hand bar is the amount of NSF funds granted in a particular region—the east north-central region and the Middle Atlantic and so forth—in percent.

The second bar represents in each case the percentage of all doctoral degrees in science and engineering, awarded in the college year 1963–64, to the geographic division in question.

NATIONAL SCIENCE FOUNDATION

UNIVERSITIES AND COLLEGES RECEIVING NSF FUNDS IN SUPPORT OF SCIENCE

FY 1964

NUMBER RECEIVING

- RESEARCH SUPPORT FUNDS 338
- SCIENCE EDUCATION SUPPORT FUNDS 850
- GRADUATE SCIENCE FACILITIES FUNDS 91
- SCIENCE INFORMATION SUPPORT FUNDS 32

TOTAL NUMBER OF UNIVERSITIES AND COLLEGES RECEIVING NSF FUNDS...914
(OF THESE, 369 RECEIVED INSTITUTIONAL BASE GRANTS)

SOURCE NATIONAL SCIENCE FOUNDATION
JUNE 1965

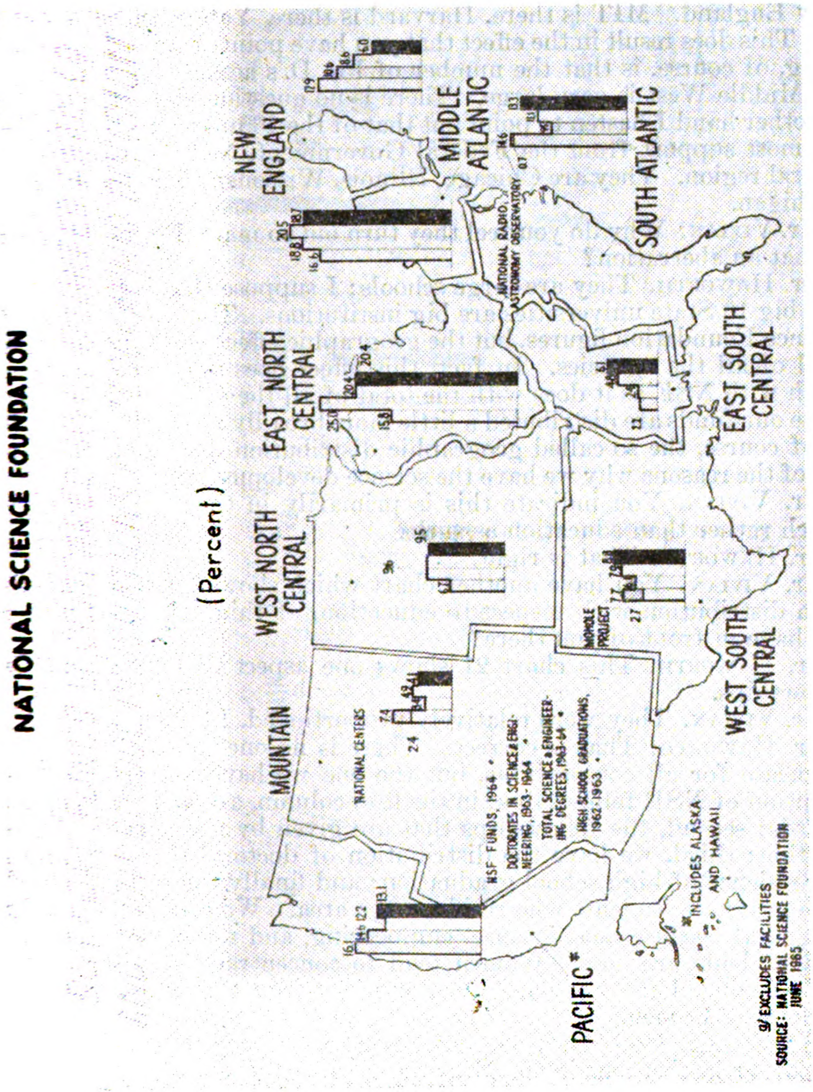
CHART 19

The next bar is the percentage distribution of total degrees in science and engineering, including bachelors, masters, and doctorates, in the same year; and finally, the fourth bar is the distribution of high school graduations for earlier years. We don't have the statistics for 1963–64, but that doesn't change the picture. We have, as you know, the three national centers, one in Arizona, one in West Virginia, and one in Colorado. Of course, they and the Mohole project are visible things and affect NSF geographic statistics, so the left-hand column for NSF has been broken down into two parts for several divisions. The top darker part represents the expenditures at a center and the bottom part represents all the rest. Only three regions are affected that way.

The chart gives an idea of how NSF support is related geographically to various educational factors. There is obviously no yardstick that is a correct yardstick, but these certainly—the number of doctoral degrees, the number of other degrees, the number of oncoming students—are certainly pertinent to the situation.

Mr. VIVIAN. I am very curious about that chart, having looked at it at some length. It seems to show that as you move west toward the Mississippi Valley region the ratio between column No. 1 and column No. 2 changes, and then it improves again as you move toward the Pacific coast. Is this because the States in the central part of the Nation have a higher level of State financing for their operations or not?

Dr. HAWORTH. There may be some impact of that sort certainly with respect to the east. I would be surprised if it is true as compared to the west coast, where there are the University of California and others. The factor is there, as you have said, there is no doubt about it.



NATIONAL SCIENCE FOUNDATION
(Percent)
NEW ENGLAND
MIDDLE ATLANTIC
SOUTH ATLANTIC
NATIONAL RADIO ASTRONOMY OBSERVATORY
EAST NORTH CENTRAL
EAST SOUTH CENTRAL
WEST NORTH CENTRAL
WEST SOUTH CENTRAL
MOHOLE PROJECT
MOUNTAIN
NATIONAL CENTERS
NSF FUNDS, 1964
DOCTORATES IN SCIENCE & ENGINEERING, 1963-1964
TOTAL SCIENCE & ENGINEERING DEGREES, 1963-64
HIGH SCHOOL GRADUATIONS, 1962-1963
PACIFIC*
* INCLUDES ALASKA AND HAWAII
a/ EXCLUDES FACILITIES
SOURCE: NATIONAL SCIENCE FOUNDATION JUNE 1965

CHART 20

Mr. VIVIAN. It is a ratio of about one and a half to one.

Dr. HAWORTH. It is in the research support, not the education support that this comes about, and it results from the fact that our research grants are given on the basis of quality, and there is, of course, a relative concentration of the very best universities in New England, in Middle Atlantic, and California. This does not mean that there aren't as good ones in the Middle West, but the portion is very high in New England. MIT is there, Harvard is there, Yale is there, and so on. This does result in the effect that you have pointed out. The other thing, of course, is that the number of Ph. D.'s actually produced in the Middle West is very large. There is no question about that. On the other hand I hasten to point out that of the 10 universities that get the most support from the Federal Government, 5 are in the north-central region. They are Chicago, Illinois, Wisconsin, Minnesota, and Michigan.

Mr. VIVIAN. Why do you feel they turn out so many Ph. D.'s there? Is that an aberration?

Dr. HAWORTH. They are large schools; I suppose that is part of it. The big 10 State universities are big institutions. These are National Science Foundation figures, but the geographic effect is similar for the total of all the agencies. In fact, this effect does not show quite as much with NSF as it does with the total of all the other agencies, because our funds are distributed a little more broadly than others. This is, of course, the so-called geographic distribution question. This is one of the reasons why we have the science development program.

Mr. VIVIAN. You indicate this is primarily in the support of research rather than education as such?

Dr. HAWORTH. That is right.

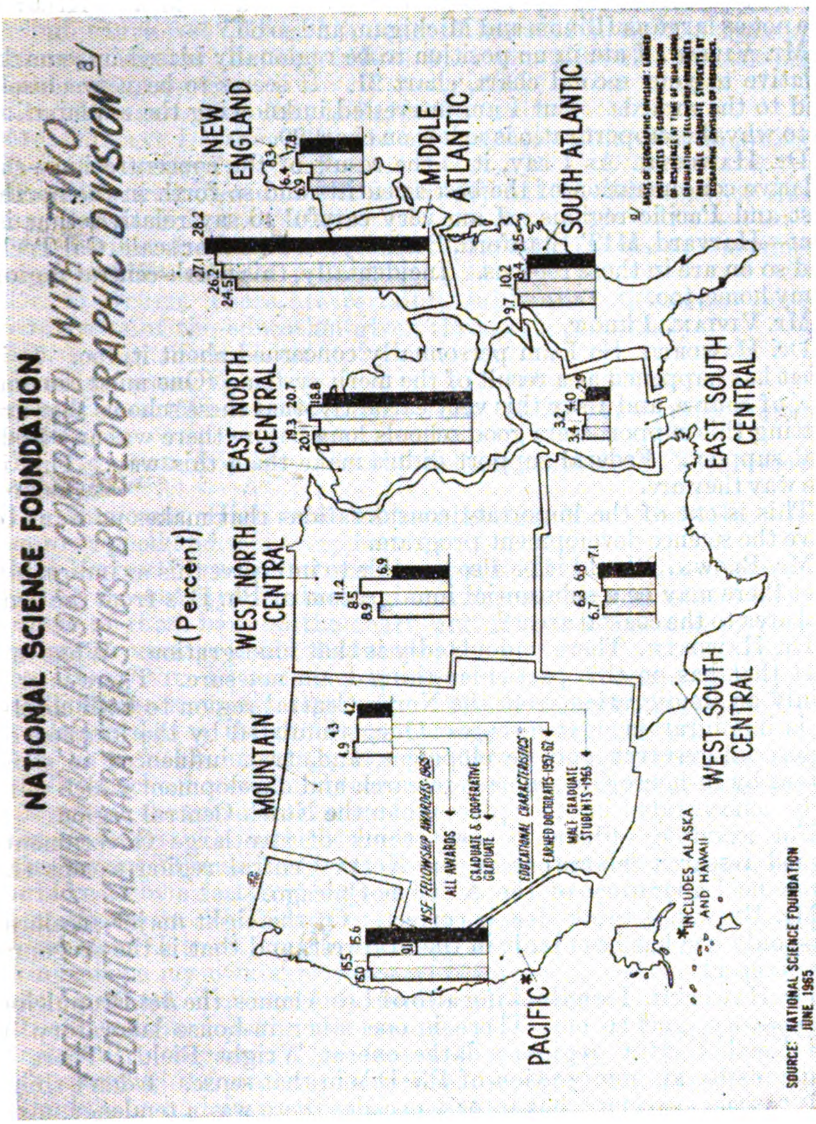
Mr. VIVIAN. You have another chart which showed a relative uniform distribution with respect to education. I think that is the one you have in front of you there?

Dr. HAWORTH. This chart 21 shows one aspect of education, the fellowships.

Mr. VIVIAN. They were relatively proportioned, I believe?

Dr. HAWORTH. That is correct. There is no one index that is appropriate for all comparisons, but the one we have here is the distribution of NSF fellowships: in the first column, all NSF fellowship awards; second, the fellowships that are given by the national competition; third, we have the distribution of doctoral degrees earned by residence of high school graduation; and finally the percent of all male graduate students who reside in the area. We used male rather than total because most science, engineering, and mathematics graduate students are men. Women tend to concentrate in other fields. If we included the women, it wouldn't be as good an index for this purpose as the men.

Mr. VIVIAN. Do I interpret your remarks correctly as follows: That the larger institutions in the Midwest are turning out a large number of students, and those are generally the ones that turn out doctorate degrees, and that these are fairly heavily supported from NSF. It must be, therefore, that the smaller school in the Midwest are not doing relatively well compared to the smaller schools in the East and the West?



NATIONAL SCIENCE FOUNDATION
FELLOWSHIP AWARDEES, FY 1965, COMPARED WITH TWO EDUCATIONAL CHARACTERISTICS, BY GEOGRAPHIC DIVISION a/
(Percent)
NEW ENGLAND
8.3 6.4 6.9 7.8
MIDDLE ATLANTIC
27.1 26.2 24.5 28.2
SOUTH ATLANTIC
10.2 9.4 9.7 8.5
EAST NORTH CENTRAL
19.3 20.1 20.7 18.8
EAST SOUTH CENTRAL
3.2 3.4 4.0 2.9
WEST NORTH CENTRAL
11.2 8.5 8.9 6.9
WEST SOUTH CENTRAL
6.3 6.7 6.8 7.1
MOUNTAIN
4.3 4.9 4.2
PACIFIC*
15.5 15.0 15.6
NSF FELLOWSHIP AWARDEES-1965
ALL AWARDS
GRADUATE & COOPERATIVE GRADUATE
EDUCATIONAL CHARACTERISTICS
EARNED DOCTORATES-1957-62
MALE GRADUATE STUDENTS-1963
*INCLUDES ALASKA AND HAWAII
SOURCE: NATIONAL SCIENCE FOUNDATION JUNE 1965

CHART 21

Dr. HAWORTH. I can't quite agree with your last remark, although, as I said, 5 of the first 10, in terms of support, are in the north-central region. There are other large institutions in this region that aren't in those five, of course. Certain ones who are getting support in California, for example, are also large institutions. The ones that are getting the most support in New England and the Middle Atlantic are not as large as Illinois and Michigan, and so on.

Mr. VIVIAN. I am in no position to be regionally biased in remarks relative to your second chart, chart 21. It seems to be very closely tied to the awards. But I am interested in knowing the explanation as to why the support ratio is so low on chart 20.

Dr. HAWORTH. As I say, it is the result of the concentration—the relative concentration of the best scientists and so forth in the northeast and Pacific regions. I am very careful to say relative, that is, that—Harvard, MIT, Stanford, Berkeley, on a smaller scale, Cal Tech, and so on are in those regions. Incidentally, this north-central region is my home, too.

Mr. VIVIAN. I know.

Dr. HAWORTH. So I am personnally concerned about it, too. It is what has happened as a result of the merit system. One must remember, of course, and I say this very earnestly, that these schools that are getting this support were good schools long before there was any Federal support. Federal support didn't make them this way. This is the way they are.

This is one of the important considerations that makes us want to have the science development program.

Mr. BROWN. Would it be also possible to interpret this as indicating that there may be a substantial immigration of Ph. D.'s from the central area to the coastal areas?

Dr. HAWORTH. There undoubtedly is that immigration. What impact that has on this particular thing I am not sure. There is certainly an immigration from the North Central region to both coasts. It is immigration in two senses: One, stimulated by the location of industrial research and development, and, two, influenced to some extent by in-house Government research and development which tend to be concentrated in other places than the North Central region.

For example, offhand, I don't think of any large Government-owned research laboratory in the North Central region except the Argonne Laboratory of the AEC in Chicago.

Mr. BROWN. I think that is correct. Of the eight major accelerators, only one has been built in the Midwest, and that is the Argonne accelerator.

Dr. HAWORTH. I am thinking also of Los Alamos, the Jet Propulsion Laboratory, and so on. There is one other in-house laboratory in the North Central region, a large one at Wright Field. There is undoubtedly an immigration of Ph. D.'s in that sense. I don't think it is so true any more, but in past decades there was a tendency, even in the academic world, for the best ones to leave the central part of the country and go, first, primarily to the east coast, in the next stage, to both the east and the west, but now they are staying home more. It is those best ones that migrated very long ago who are partly responsible for the fact that grants tend to be concentrated now on the east and west coasts.

Mr. VIVIAN. Do you have any yardstick on performance, in terms of quality of education, which would apply at the bachelor's level or the master's level? I don't imagine there is any qualitative measure at the Ph. D. level which would allow you to determine the relative quality of the various institutions across the country?

Dr. HAWORTH. There is certainly no really objective yardstick. It is a subjective feel that each individual has who knows the situation.

Mr. VIVIAN. At the high school level you have the various high school testing systems.

Dr. HAWORTH. Yes, that is right.

Mr. VIVIAN. Do they indicate any relative difference in quality across the country?

Dr. HAWORTH. Some, but it is awfully hard to tell whether there is any innate difference at all.

Mr. VIVIAN. I am referring only to the effectiveness of the education given the students.

Dr. HAWORTH. There are certainly substantial differences in the effectiveness of the education given through high school.

Mr. VIVIAN. That shows up?

Dr. HAWORTH. Yes.

Mr. VIVIAN. Where would that show at its lowest and highest points?

Mr. CONABLE. We have already talked about New York State's problems.

Dr. HAWORTH. High school educationwise, New York State has some very good and some very bad.

Mr. VIVIAN. I am just trying to track down the question as to whether the quality of education is a factor, as well as the height of some of those bars on the chart, and if it is a question of rising through the various levels of education.

Dr. HAWORTH. The quality certainly varies. It varies locally, as we all know; it varies regionally. The differences regionally are not always due to the difference between school districts.

Mr. VIVIAN. For example, is a Ph. D. or a master's degree from a Midwest school considered to be as good an educational experience as, say, from the two coastal areas?

Dr. HAWORTH. From the best ones, yes.

Mr. VIVIAN. Then, there is no obvious reason why the support ratio should be off by a factor of $1\frac{1}{2}$ to 1?

Dr. HAWORTH. We have to take into account the past as well as the present. I know time is fleeting, but could I spend 3 minutes talking about my own experience with respect to this problem?

Mr. DADDARIO. You certainly can, Dr. Haworth.

Dr. HAWORTH. I got in the business of science and science education awfully long ago; I graduated 40 years ago from college, so I have watched it for a long, long time. In the first place, this country hadn't been doing academic research on any appreciable scale for very long in the 1920's, it was primarily a European activity, but there were a few American universities who were beginning. Some had been doing it for quite awhile. There was Harvard, Yale, Princeton, Columbia, and so on, who were the leaders in the East. In the Middle West there were only three that were doing any appreciable amount of research across the board, although others were

in some fields. Those three were Michigan, Chicago, and Wisconsin. For example, there was good chemistry at Illinois, but there was practically no research in physics. I graduated from Indiana, and in those days there was virtually no research at Indiana. On the west coast, when I graduated from high school, Cal Tech was not well known, there was little or no research there; it was known as the Throop College of Technology. In 1921 they got R. A. Milliken as president. Milliken was a Nobel Prize winner and he was a very great physicist. He decided to go there and build up this institution; the name was changed about the same time. He began to get new people, and by the 1930's, about 15 years after he went there, this had become a small but very high quality institution. It had some very good people. That is one of the points I wanted to make. It is really people and ideas that make these things.

Berkeley had not been up to that time a very thriving center, but there were some people like Lewis in chemistry and Ernest O. Lawrence, who went into physics in the late twenties—who invented the cyclotron and so forth—who built that up. Some good people went to Stanford at about the same time. So the west coast began to build up. In 1928 Karl Compton became president of MIT, which had been just what its name implies, a technological institute, and an excellent one. But it was not a research institution or a graduate institution in anything like the sense it is now; it began to build up and by World War II it had become this kind of an institution.

At Illinois—and I have to speak mostly of physics and chemistry, mostly physics, a little of chemistry and math, because these are the fields that I have had personal experience in—in 1928 in Illinois they brought as chairman of their physics department, Dr. Loomis, and by the end of the war they had a very good department, and Roger Adams brought in very good people and built up one of the finest chemistry departments in the country.

Wisconsin kept building up. One of the important things there was that Dr. Steenboch devised the scheme of irradiating milk to get "vitamin D milk," and the Steenboch patent was turned over to the university. They founded the Wisconsin Alumni Research Foundation, and the income from just that patent—other patents were added but that one had widespread application of course—provided lots of funds and the university went ahead rapidly in research.

So there has been a constantly growing number of new places. But all the ones I have mentioned grew on their own before the war. Well, the process has continued, but the highest of the high spots throughout these regions, as I say, started in the East and in the West and a little bit later in the East North Central area.

Mr. VIVIAN. I think if I were to ask you to draw another bar which would show the number of Nobel laureate awards, it would be very high on the California side.

Dr. HAWORTH. Yes, it certainly would.

Mr. VIVIAN. If you were to draw another bar on there which would show where they gained their doctorate degrees, do you think that would be uniformly spread or not?

Dr. HAWORTH. I suspect it would. I think you would probably have to make an average differentiation. Are you talking about the Nobel laureates?

Mr. VIVIAN. I am referring to where the Nobel laureates received their training.

Dr. HAWORTH. I think they would still concentrate in the East and the Far West, but not so much among the younger ones as the older ones.

Mr. MOSHER. Mr. Chairman, I suspect it would be an interesting study of some significance to know where some of these men got their original inspiration in undergraduate work: For example, Milliken at Oberlin, Compton at Worcester, there are certainly undergraduate schools that have had a big influence.

Dr. HAWORTH. Yes, there is another one out in the Dakotas, where Ernest Lawrence and two or three other famous scientists were undergraduates. In fact, there is one high school that they went to.

Mr. DADDARIO. When Mr. Vivian asked you about the Nobel Prize winners, where they got their training, I thought I heard someone in the audience say half of them would probably be from Europe.

Dr. HAWORTH. No. I have forgotten numbers, but before the war, of course, most of the Nobel Prize winners not only got their training in Europe but they also lived in Europe.

Mr. DADDARIO. The actual number is not so important.

Dr. HAWORTH. Actually only on the order of 10 percent of American Nobel Prize winners came from Europe. It used to be true. An interesting thing is in the last 12 years exactly half of the Nobel Prize winners in the sciences have been Americans, and of those Americans I think about 10 percent were born in Europe.

Mr. BROWN. Following up on this very interesting discussion you made about the spread in the development of these outstanding institutions, haven't we seen a continuation of that phenomenon within the last few years?

Dr. HAWORTH. Oh, yes.

Mr. BROWN. Developments have taken place in Texas and in other places in the South. Isn't that really what we want to encourage?

Dr. HAWORTH. Yes. It has kept going, the same thing. There are more and more good institutions. I confined myself to the prewar history because there was no Federal fund influence then. It has kept on. There are many very good institutions now. They still may not have caught up with the leaders, but they are at the stage that the leaders were not terribly long ago. For example, in the State I grew up in, in Indiana, Indiana and Purdue are now both very good graduate universities. To Michigan has been added Michigan State, and Wayne is getting to be a very good place. I am speaking now of the larger ones. Minnesota I wouldn't have mentioned back in the 1920's or 1930's as one of the leading ones, but it now is. You can say the same thing in other areas of the country.

Mr. VIVIAN. I wonder if I could ask you to provide me for the record a similar chart showing the distribution of funds for the training of students up through the high school level and the training of their instructors. In other words, I would like to limit the subject strictly to the training that terminates at the high school level for both the students and the instructors.

Dr. HAWORTH. You are speaking of the support for this?

Mr. VIVIAN. Yes.

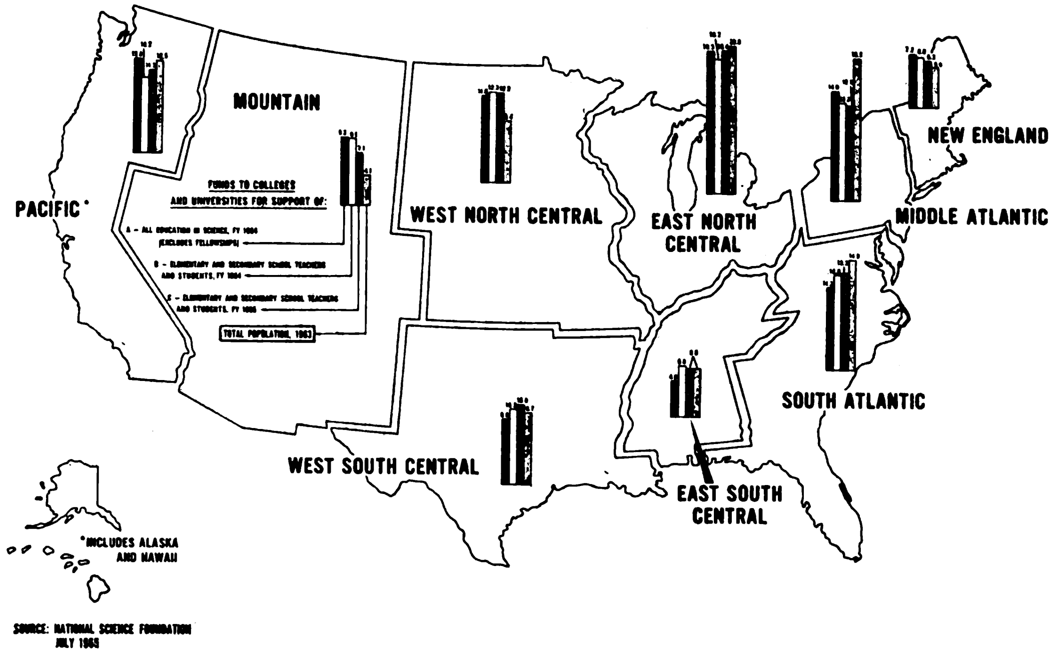
Dr. HAWORTH. We will be glad to give this. I would like to point out one thing, that in terms of the effect on the students—well, even the teachers—such a tabulation is not necessarily too meaningful for the following reason. A college in Tennessee may hold a teacher's institute in the summer but draw its students from many States, and we have no knowledge of that. That is, not the students, but the teachers attend the universities, so the teachers are affected and, in turn, the high school students that are affected are not necessarily distributed in the same pattern as the funds given to the institutions. We will be glad to give the information, but you must bear that in mind when you study it.

Mr. DADDARIO. Would you supply whatever you can for the record.

(The information requested is as follows:)

NATIONAL SCIENCE FOUNDATION

PERCENT OF TOTAL SUPPORT BY REGION FOR ELEMENTARY & SECONDARY SCHOOL TEACHERS & STUDENTS (FY 64 & 65) COMPARED WITH ALL GRANTS TO COLLEGES & UNIVERSITIES FOR EDUCATION IN SCIENCE, FY 1964, & TOTAL POPULATION, 1963



PERCENT OF TOTAL SUPPORT BY REGION FOR
ELEMENTARY & SECONDARY SCHOOL TEACHERS & STUDENTS (FY 64 & 65)
COMPARED WITH ALL GRANTS TO COLLEGES & UNIVERSITIES FOR
EDUCATION IN SCIENCE, FY 64, & TOTAL POPULATION, 1963

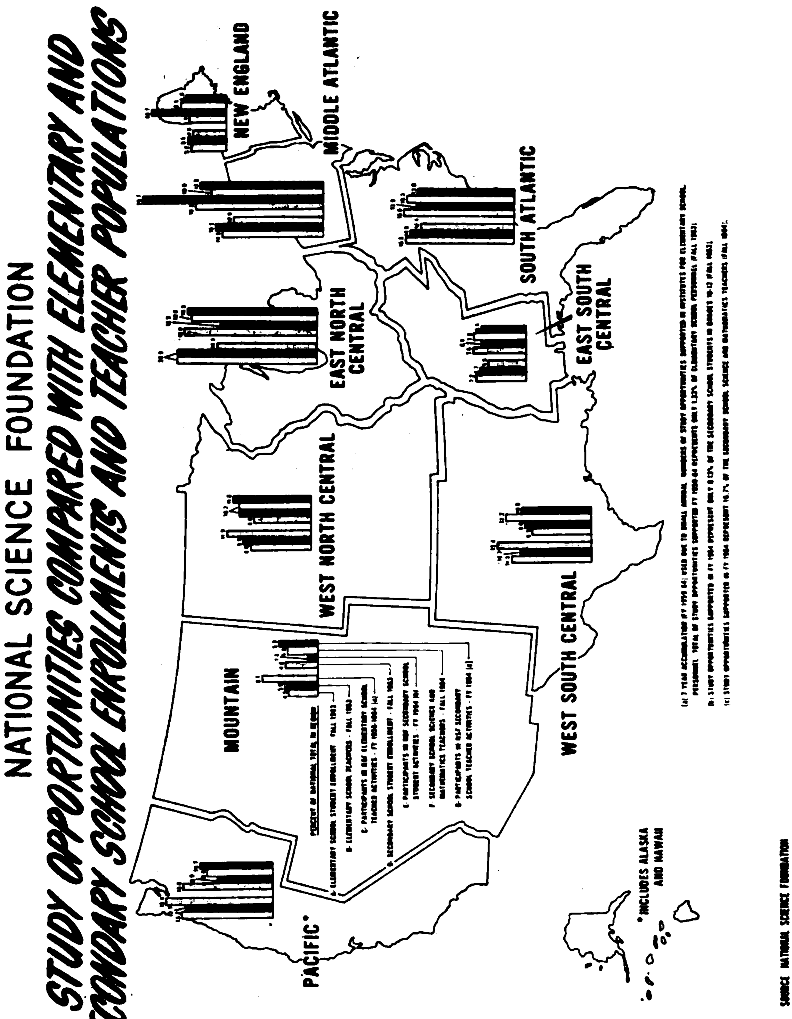
Funds for Support of:

	Education in Science Grants[1] FY 1964		Training for Elementary and Secondary School Teachers/Stud.[2] FY 1964		FY 1965		Total Population 1963	
	Amount[3]	% of Total	Amount[3]	% of Total	Amount[3]	% of Total	Number[3]	% of Total
New England	$ 5.8	7.2	$ 3.0	6.8	$ 2.8	6.3	10.8	5.4
Middle Atlantic	12.0	14.8	5.8	13.2	5.9	12.9	35.6	19.2
East North Central	15.3	19.3	8.1	18.2	8.7	19.4	37.2	20.0
West North Central	9.5	11.8	5.4	12.3	5.5	12.3	15.7	8.4
South Atlantic	8.9	11.2	5.7	12.9	5.9	13.2	27.7	14.9
East South Central	4.0	4.9	3.1	6.9	2.9	6.6	12.4	6.6
West South Central	7.2	8.9	4.5	10.2	4.9	10.8	18.1	9.7
Mountain	7.4	9.2	4.0	9.1	3.2	7.1	7.6	4.1
Pacific	10.3	12.8	4.5	10.2	5.1	11.3	23.4	12.5
Total	$80.3		$44.2		$44.8		186.0	

1 Funds granted in FY 1964 for support of proposals received from colleges and universiti in 50 states and D. C. Includes Traineeships, Institutes, Research Participation and Scientific Activities for Teachers, Undergraduate Research Participation and Instructional Scientific Equipment, Secondary School Student Program, Course Content Improvement and Advanced Science Education Projects. Excludes Fellowships.

2 Includes all Institutes, Conferences, Research Participation and other supplementary training activities for elementary and secondary teachers plus special courses and research participation activities for secondary school students.

3 In millions


NATIONAL SCIENCE FOUNDATION
STUDY OPPORTUNITIES COMPARED WITH ELEMENTARY AND SECONDARY SCHOOL ENROLLMENTS AND TEACHER POPULATIONS
NEW ENGLAND
MIDDLE ATLANTIC
SOUTH ATLANTIC
EAST NORTH CENTRAL
EAST SOUTH CENTRAL
WEST NORTH CENTRAL
WEST SOUTH CENTRAL
MOUNTAIN
PACIFIC*
*INCLUDES ALASKA AND HAWAII
SOURCE NATIONAL SCIENCE FOUNDATION

STUDY OPPORTUNITIES COMPARED WITH ELEMENTARY AND SECONDARY SCHOOL ENROLLMENTS AND TEACHER POPULATIONS

Regions	Elementary School			Secondary School			
	Student Enrollment Fall 1963 1/	Number of Teachers Fall 1963	Teacher Participants 2/ FY 1959-64	Student Enrollment Fall 1963 1/	Student Participants 3/ FY 1964	Sci. & Math. Teachers Fall 1964	Teacher Participants 4/ FY 1964
New England	1,338 (5.2)	49,865 (5.5)	575 (4.8)	746 (5.4)	1,059 (10.7)	14,090 (6.5)	2,176 (6.0)
Middle Atlantic	3,753 (14.5)	141,738 (15.5)	1,552 (12.9)	2,639 (18.2)	2,537 (25.7)	34,890 (16.0)	6,329 (17.5)
East North Central	5,154 (20.0)	181,637 (20.0)	1,721 (14.3)	2,713 (19.0)	1,372 (13.9)	39,160 (18.0)	6,708 (18.5)
West North Central	2,221 (8.6)	86,148 (9.5)	1,435 (11.9)	1,143 (8.0)	1,005 (10.2)	22,050 (10.2)	3,973 (11.0)
South Atlantic	3,995 (15.5)	134,745 (14.9)	1,606 (13.4)	2,283 (15.8)	1,369 (13.9)	33,370 (15.3)	5,081 (13.8)
East South Central	1,843 (7.2)	60,477 (6.7)	665 (5.5)	1,084 (7.6)	634 (6.4)	16,310 (7.5)	2,307 (6.4)
West South Central	2,956 (11.5)	92,816 (10.2)	1,603 (13.4)	1,222 (8.5)	945 (9.6)	26,560 (12.2)	3,625 (10.0)
Mountain	1,150 (4.5)	45,120 (5.0)	976 (8.1)	692 (4.8)	156 (1.6)	10,070 (4.6)	2,157 (5.9)
Pacific	3,408 (13.2)	115,990 (12.7)	1,850 (15.4)	1,880 (13.0)	781 (8.0)	20,960 (9.6)	3,892 (10.7)
Total	25,817	908,536	11,983	14,400	9,858	217,460	36,248

1/ In thousands.
2/ Includes all study opportunities for elementary school teachers in institutes from FY 1959-1964.
3/ Includes special courses and research participation activities for secondary school students in FY 1964.
4/ Includes all institutes, research participation, fellowships and special training opportunities for secondary school teachers in FY 1964.

NOTE - All numbers in parentheses are the percent of the total.

Mr. Roush. A couple of years ago, maybe 3 years ago, an official of the Defense Department made a statement in Chicago that one reason there was not a more equitable distribution of Federal support funds for research, development and procurement was that there was an "intellectual vacuum" in the Midwest. That is the reason the Midwest was neglected. This was echoed again by the Secretary himself. Your chart wouldn't indicate that. Would you care to comment?

Dr. Haworth. I wouldn't agree with that statement. What I am about to say has nothing much to do with the NSF, but I would like to comment just a minute on this broader problem, and that is, of course, the largest concentration of funds away from the Midwest, if you want to put it that way, or on the two coasts, is not in research funds or in academic funds but in development funds. The electronic business in New England, and the aerospace business on the Pacific coast, for example, are actually, in my opinion, simply the result of past history. Part of the Middle West and as a matter of fact parts of the East were the mass producers long before the war, the mass producers of consumer goods; the automobile industry, the steel industry and so on. During the war the mass production of armaments was done in the Midwest. Look what Detroit and Willow Run did in the way of tanks and airplanes and so on. The heaviest concentration of R. & D. was in New England and on the west coast, and there wasn't much in the Middle West because they were doing the other armaments job. At the end of the war the Middle West, and I am saying the Middle West just because this seems to be the place that we have talked the most about, reconverted to the production of consumer goods, appropriately so.

New England happened to be a region that was losing some of its old industry, the textile industry, and so forth. On the other hand, it had been a place for concentration of certain activities—the radar development at MIT, the countermeasures development at Harvard, and things of that sort. Individuals who went there during the war stayed there afterward. They liked it there and they set up their little companies.

Then in the region around Stanford University, there was a very strong electronics group. The Klystron was invented there before the war by Bill Hansen. It had Fred Terman, who is an outstanding electrical engineer. And the same sort of thing tended to happen there. This really goes back to prewar and wartime history. There still is great production in the Midwest. The Federal Government certainly buys lots of things from the Middle West. I think actually the difference is in industry and not in the universities.

Mr. Roush. Dr. Haworth, I have been interested in this matter of geographic distribution, trying to avoid being provincial even though I am from the Midwest. It has seemed to me that it is in the national interest that we consider this problem. Of all the agencies of the Government which really have contributed to a geographical distribution of Federal funds in research, I think your agency has done the most. I think this is due to a couple of reasons. One is your funds go to basic research, where we do not have the question of mission being considered. Secondly, and what I think is most important, is that this was part of the intent of Congress when the National Science Foundation was created.

In reading the background material for these hearings, it appears that there has been a gradual and perhaps unconscious turning from this admonition, slight, perhaps, but still it is there. It seems to me the point raised by Mr. Vivian gives credence to this thought and indicates that perhaps you now are contributing—and it is beginning to become significant—to the concentration of research and development on the two coasts by reason of the funds ratio shown on this chart as compared to the degrees awarded at these various institutions.

Dr. HAWORTH. I can't find any evidence that the NSF distribution is any more concentrated now than it was. In fact, what little evidence I can find, going back far enough to be significant, is that it has been going the other way. It certainly has been spreading out among institutions. That, of course, you can expect. The first year NSF only had a small sum of money. If you only had a hundred thousand dollars, you might give it all to one university, but if you have a hundred million dollars you are obviously going to give it to more than one university. So the larger the support you get, the more it is going to spread. I fully subscribe to all the implications of your remarks, as I said before, but the Midwest is not the only place in question. For example, what we need to do in the South for the good of that region and the good of the country, is very important.

Mr. ROUSH. I thoroughly agree with this. But if your awards are made solely on the basis of merit, it is only natural that these people who have great competence in those fields will migrate to those areas where there is presently an outstanding competency on the part of the universities or industry. Therefore, it will be only natural that your funds will go to those areas if this is the main criteria of your awards; isn't this true?

Dr. HAWORTH. There is certainly going to be some of that, but that is precisely why we are trying to have other programs that counteract this tendency. Frankly, in a given research program conducted by the Foundation, I don't see in awarding, say, 25 grants out of 50 applications how we can balance the question of reasonable distribution against the question of merit within that program. I believe we should have two kinds of programs, one of which is purely a merit program and the other of which is avowedly to build up strength in certain places.

Mr. WAGGONNER. When that second program starts achieving its purposes——

Dr. HAWORTH. They begin to compete.

Mr. WAGGONNER. I think the charts are misleading because we are talking about dollars and cents as related to the number of degrees awarded. This is misleading because you get a picture which does not relate to the total number of people that we are talking about.

Dr. HAWORTH. You mean the total population?

Mr. WAGGONNER. The total population as such. There is a direct relationship. For example, geographically speaking, we have some small areas but we have mass concentration of population. In other places we have big areas but it is sparsely populated. We have to relate all those factors to get the picture here. The thing that is deceiving when you look at the bar chart, one looks small and the other looks large, and it distorts it.

Dr. HAWORTH. The question here, of course, is the chicken and the egg, and I am not giving any implication in stating the question: Is the National Science Foundation the one to build up stronger high schools, stronger grade schools, a tendency to go to school at all in various regions of the country, and to what extent should it, on the other hand, put its funds where the strength already is? What I am trying to say is I think we have to look at it from both sides, look at it with both eyes, and I think you have to keep the two objectives somewhat separate.

Mr. WAGGONNER. This is the reason we have to have two programs, as you say.

Dr. HAWORTH. That is right. Now, the President's general education programs, of course, are directed at the business of building up the general level of education and attainment and so forth throughout the country. That is still another aspect of it.

Mr. WAGGONNER. After all, it is impossible for you to accomplish anything no matter how good your program might be if you do not have some initiative and some cooperation from the people back at the grassroots?

Dr. HAWORTH. That is right. And all of these places that I spoke of earlier that are good institutions—and I hope anybody whose institution got left out will realize there are a great many good ones I didn't mention—all of these institutions built up on their own. Sure, since the war, they have received Federal support, but earlier it took initiative, good ideas, and people who wanted to build the institutions.

Mr. WAGGONNER. New England and the Far West are good examples of that.

Dr. HAWORTH. That is right. They are good examples. Of course, they have had the tremendous growth of students. The place where the East has lagged quite frankly is in public universities.

Mr. WAGGONNER. Facilities in public universities?

Dr. HAWORTH. That is right.

Mr. WAGGONNER. They haven't expanded their facilities as other areas have?

Dr. HAWORTH. That is right.

Mr. VIVIAN. Dr. Haworth, 2 days ago you stated you were following a policy, roughly as follows: If you came to a situation where two proposals were roughly equal in quality, that you would tend to give preference to that proposal which was from a geographically less well-off area. Is that a correct restatement or not?

Dr. HAWORTH. I actually make that statement about the fellowship programs. I have to say it a little differently for the research. We tend to think of it this way. There are really three things. We have to maintain the quality of the best institutions and give them good support, in the first place, in order to get good research done, and in the second place, in order to educate the high quality students that go there. Incidentally, it is very important to the universities all over the county that good people come out of Harvard and MIT and so on. Such institutions are the wellsprings, the sources of the best people. The second thing is we have to have more good institutions wherever they are. The third thing—and I don't put any order of priority here—is that as we build up institutions, let's build them up so that all regions of the country have good institutions.

In the first instance, when our funds were small, the distinction was probably made institutionally rather than regionally, but more and more it is being made regionally as well as just institutionally. Other things being equal the aim is to spread funds among more and more institutions.

Mr. VIVIAN. Does that suggest if we appropriate more funds for NSF next year you will spend more in the Midwest?

Dr. HAWORTH. There would be more everywhere.

Mr. VIVIAN. That isn't the way I worded the question.

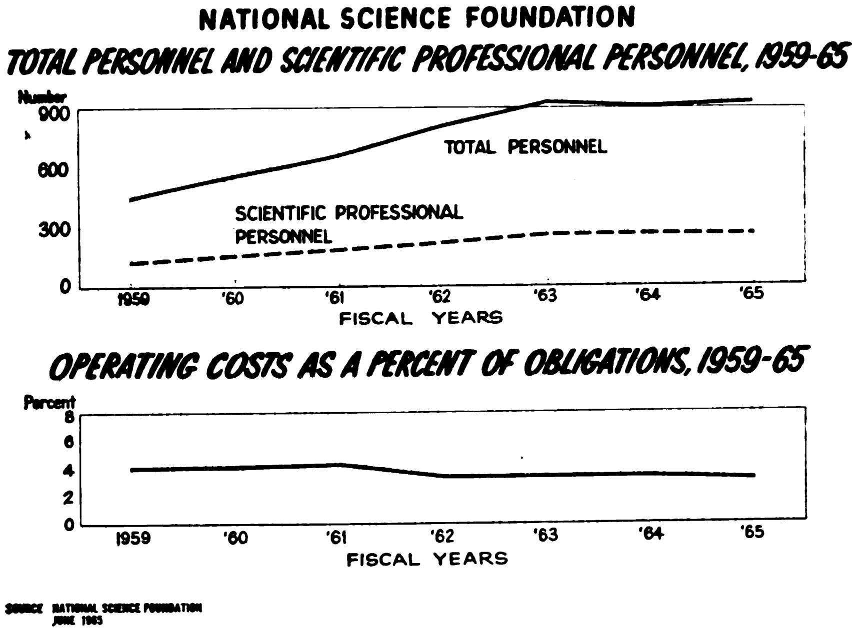


CHART 22

Dr. HAWORTH. Chart 22 is one I thought you might be interested in. It shows how much we spend inside the Foundation for administration. It simply shows the level of total personnel and of scientific and professional personnel over the last 6 or 7 years and the operating cost as a percentage of the obligations. It has actually gone down a little bit.

I think maybe it would be better if you permitted me to read this last statement and to bring in the last two charts at the appropriate place in the statement. You remember that this was the sequence I suggested we follow the first day.

Mr. DADDARIO. I understand the statement you are reading now is the one dated June 24.

Dr. HAWORTH. Earlier in this presentation I have attempted to give you a reasonably complete understanding of the Foundation's present place in the Federal science-support complex, and to tell you what we have been and are at present doing. Let me now try to place NSF in the Federal science structure of the near and long-range future.

Let us briefly analyze the present situation. The lifetime of the Foundation has been a relatively brief span of 15 years. This has been a period of great growth in American science and, relatively speaking, of even greater growth in Federal sponsorship of that science. Just as in research, the methods of support, the relationships with non-Federal institutions and many other aspects of methodology had to be explored. Especially in the early days, attention had to be devoted to those areas where support was crucial to the immediate progress of the country. Many techniques and policies were tried, most have been successful. Inevitably the advances have been made by driving salients—all of them important. Equally inevitably, some fronts have lagged behind.

As this committee has wisely seen, now is a time for retrospection and consolidation—to view the campaign as a whole, to plan the future strategy, to look to the longer range objectives. In what follows I shall attempt to call attention to some of the factors that may be involved.

As time moves on, I see NSF accepting a heavier financial responsibility on behalf of all Federal agencies for an expanding basic science. I believe that all agencies should and will continue to support basic research, as they now do, but NSF is likely to be thought of as the logical agency to meet a major fraction of new and expanding requirements.

There is wide agreement that Federal support of scientific research should expand, particularly in the universities. A substantial portion of the basic research conducted in the United States is carried out by professors and other scientists at such institutions. As you all know, this research is particularly important to the future of the country for two principal reasons: first, most of the research performed at academic institutions lies at the frontiers of scientific knowledge and thus is most likely to contribute to the strength of our science and technology in the long run; second, such research is an essential ingredient in training future scientists and engineers—both because student participation in research is essential at the more advanced levels of education, and because research stimulates and improves the facilities.

In recognition of these facts the President, in his budget message to the Congress this year, called for an appreciable increase in support of academic research. Furthermore, he assigned a special responsibility to the National Science Foundation for providing an increased proportion of Federal support for such research. The Congress has consistently supported academic science; as a recent example, in our appropriation bill passed last month, the House of Representatives explicitly endorsed our efforts to increase the number of centers of scientific excellence throughout the country, thereby reaffirming the importance of strong programs of support in educational institutions. The recent report submitted by the National Academy of Sciences to the Committee on Science and Astronautics, stresses the requirement for an expanded Federal effort in the support of basic research. Thus, there is general agreement in the executive branch, in the Congress, and among representatives of the academic community that the Federal Government must continue to assume a major share of the responsi-

bility for adequately supporting basic research in institutions of higher learning, including provision for an appropriate rate of growth.

The need for increasing support arises from three causes: first, many first-rate scientists are not now given support adequate to permit them to reach their full effectiveness; second, support must be provided for increasing numbers of faculty members and graduate students as academic institutions expand their enrollments to meet national needs; it is estimated that this increase will be some 8 or 10 percent per year, for many years to come. Finally, we must provide for the fact that the cost of research per scientist constantly increases, primarily because the growing complexity of research required the use of more sophisticated equipment and additional supporting personnel. The annual increase in cost per scientist is estimated at some 5 to 7 percent.

If we combine these estimates, we find that each year we will need an overall increase of 15 percent or more in support of research in academic institutions merely to maintain a constant relative level of research effort in those institutions—to hold our own, so to speak. Because we recognize fully the imprecise nature of this 15-percent estimate, constant efforts are being made to discover better ways to determine these future needs. For example, consideration of this problem will form an important part of a study of basic research, particularly at the universities, which will be carried out this summer by a panel of the President's Science Advisory Committee. This study is regarded as a significant step in a continuing effort to understand and analyze these problems. The Foundation is partaking in and is providing a major component of the staff work for this effort.

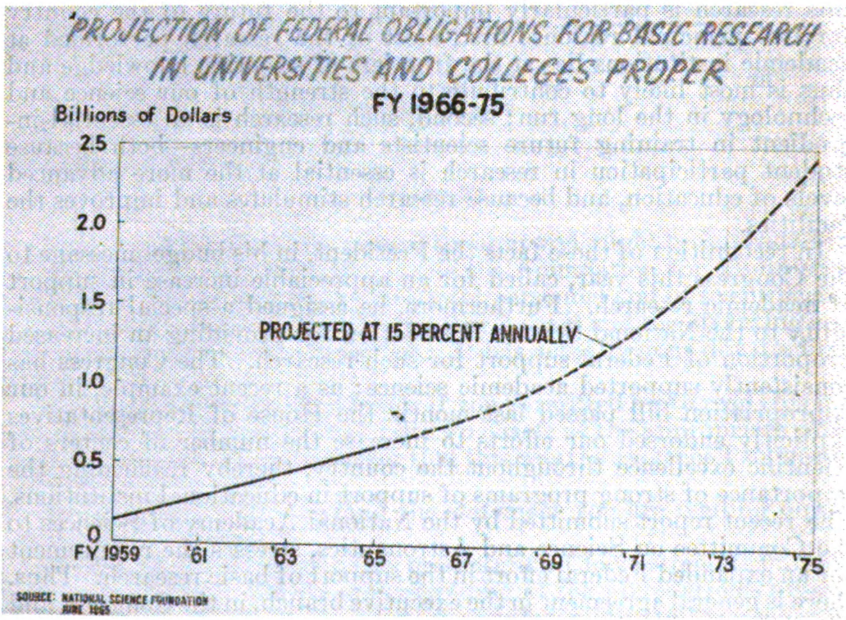


CHART 23

NATIONAL SCIENCE FOUNDATION

PROJECTION OF NSF OBLIGATIONS FOR BASIC RESEARCH IN UNIVERSITIES AND COLLEGES PROPER

1966-75

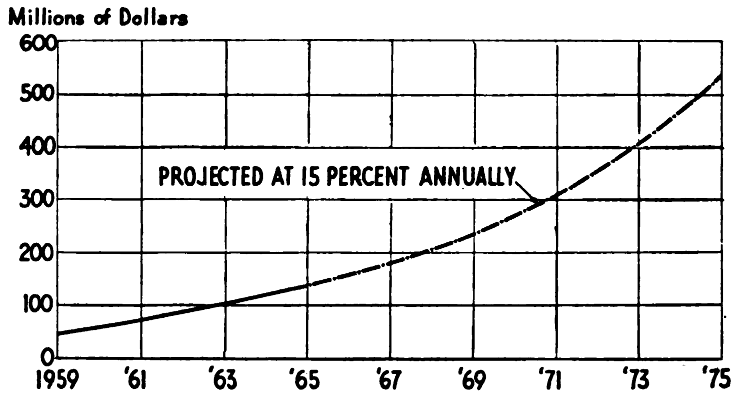


CHART 24

Here is where I might stop and allude to charts 23 and 24. These charts give you an idea of what the future would hold if the Foundation and the Federal Government, as a whole increased academic support by 15 percent annually. The Foundation is engaged in basic research with only one or two exceptions, but the Federal support of basic research in universities and colleges is just about half the total Federal support of research and development in universities and colleges.

Mr. WAGGONNER. Will this 15-percent annual increase change that ratio?

Dr. HAWORTH. I see no reason to think so because actually the 15 percent I alluded to is meant to be a rough estimate of the rise in support of research needed in colleges and universities, be it basic or applied. I see no reason to expect any change in the ratio of basic to applied research. At this time the Federal basic research support in chart 23 represents about half of Federal research and development support to colleges and universities. A large fraction of the support is by NIH. As I recall, NIH classifies about 60 percent of their support as applied. You can see if this rate of increase were indeed followed—I make no claim, as I have said, for any precision in this estimate, but it is just some kind of a guideline—Federal basic research support at universities proper would reach nearly \$2½ billion 10 years from now.

Chart 24 shows what would happen if NSF maintained a constant fraction of the Federal total in chart 23. Then NSF support in universities and colleges proper—again when I say proper, I leave out the contract research centers—would grow from its present level of about \$130 million to a little under \$540 million.

Mr. DADDARIO. Do you base that raise on the percentage of your growth to this date?

Dr. HAWORTH. This is just using the analysis of support that I read while you were out of the room. It is also the same one that Dr. Brooks has in the Academy report to the committee. It is estimated that the number of students and therefore the faculties will have to increase about 10 percent each year and that the cost of doing research because of its increased complexity, the use of computers, etc., goes up about 5 percent per year. So as a crude guideline one might estimate that to keep things going as they are in the universities it would take at least 15 percent per year even if support were adequate now, which I don't quite concede. So the 15-percent rise is not necessarily related to the past, although for the total Federal Government it is in the same ball park as in the past.

Mr. DADDARIO. What do you base the 15-percent estimate on? What is your beginning point?

Dr. HAWORTH. Let me talk about the total Federal support.

Mr. DADDARIO. I am referring to the total Federal support for the moment.

Dr. HAWORTH. The oncoming wave of students which hasn't hit the graduate schools yet is going to cause rises in enrollment of 8 to 10 percent each year for many years.

Let's assume that about the same proportion go into graduate school as now, and of those the same proportion go into science and engineering and mathematics—actually that proportion is increasing a little bit or has over the past 15 years; it goes up and down. Let's assume that we have to have a proportionately larger faculty to take care of these students. Then this means that at the graduate level the universities will grow about 10 percent per year. So if you are going to give support to the students and faculty in the same degree that you are now, that would call for a 10-percent rise. However, research continues to cost more and more. I am not now thinking of inflation in the usual sense, but just that research gets more expensive as it gets more complicated. It takes more complicated equipment, more people to run the machines, and this is estimated to account for from 5 to 7 percent. So taking the 8 to 10 percent, on the one hand, and the 5 to 7 percent, on the other, you come to the combined figure of about 15 percent. It is crude, but it is a guideline.

Mr. WAGGONNER. It is a guideline to maintain the present support without closing the gap?

Dr. HAWORTH. That is right.

What has been happening recently is that the mission-oriented agencies have not been increasing their support of university research, or of basic research generally, as rapidly as they did in the past. They are going up, only about 10 percent. This is determined by the needs of their missions because they do not have a direct responsibility for the universities and colleges as we do—that is, agencies such as the Defense Department and the AEC do not. They all do their best, but their missions have to take first priority. So, since they are going up only about 10 percent, if the total is going up 15 percent, we have to go up more than 15 percent.

As a matter of fact, in constructing the budget this year, this was all taken into account. The amount requested in the NSF research budget, the one before the Congress, the budget for 1966, was held undetermined until the last minute, until the budgets of the other agencies, NIH, DOD, AEC, and so forth, had been more or less finished. Then the situation was analyzed to see how much shortfall there was going to be with respect to the curve of chart 23. The necessary increment in NSF's support was calculated to be about 15 percent on its own previous support, plus the shortfall in the other agencies, estimated at $50 or $55 million. So the President's budget included that extra amount in the NSF budget in order to make up for the fact that the other agencies were not going up as much as was deemed necessary to support the research in the academic institutions. That was the detail of what I referred to in my prepared statement.

I have actually, Mr. Chairman, just said in more detail the next paragraph in my written statement, so I won't take time to read it. We will go on to the first paragraph on page 5.

In stressing the importance of research in academic institutions and the need for it to grow, I do not mean to neglect the important role played by the national research centers. They must continue to be supported and their programs should be strengthened and expanded. Perhaps from time to time there may be occasion to establish more of them in special fields. For example, I expect that, once it reaches the research stage, Project Mohole will be operated as such an activity.

These centers are national because they serve the Nation in several ways. They provide centralized resources for the conduct of research—including specialized equipment and scientific services that are beyond the scope of most universities. Scientists from institutions throughout the country may freely avail themselves of these resources and may, in fact, work jointly with the permanent center staff on continuing research problems. Thus the centers are essential both to the effective advancement of science and to the health and vigor of the traditional institutions engaged in such research. An important feature is the opportunity they provide for graduate students and especially young postdoctoral scientists to undertake advanced study and training.

Let me turn now to some important questions regarding the nature of our support at academic institutions. The first of these might be stated thus:

How and to what extent can individual higher education institutions, as a whole, be most effectively strengthened by Federal support of research?

It is essential that these institutions indeed be strong. Although each is dependent upon the individual talents of its faculty, those talents flourish best in a vigorous environment—one that stimulates intellectual achievement and provides the means for such achievement. In a very real sense institutional strength can provide a situation in which the whole is greater than the sum of the parts. Furthermore, without such strength the institution cannot retain the services of the outstanding individuals on which success depends.

Let us look at our methods of research support in the context of this question. The project system had its origins in the fact that the mission-oriented agencies with a desire to support research in their own fields of interest provided the early postwar support. They received proposals for specific programs of research and judged them individually. As I have said, the Foundation has used this system from the beginning and—in common with some other agencies—incorporated the help of advisory panels.

This system of "judgment by the peers" turned out to be a great invention. It brings into the evaluation process the most highly qualified scientists in the country and is, furthermore, a protection against the possibility of errors in judgment that might result were programs determined by a relative few within the Government who were not in immediate and constant touch with progress in the various fields.

This system is still sound, useful and vigorous. We will have it with us for a long time to come. Individual scientists generally favor it over any alternative method thus far put forward. Its disadvantages are recognized, but its advantages are far more weighty.

Mr. VIVIAN. I have a question relative to the "judgment by peers" approach, which you are following and which I personally regard highly. Is the same system utilized to a significant extent by other agencies who are granting research contracts and grants?

Dr. HAWORTH. NIH has essentially the same system, in some sense a more formalized system than we do. Other agencies use it partially. The Atomic Energy Commission does not use it at all, in this same sense for judging individual proposals. As I understand, it is used in some places in DOD.

Mr. VIVIAN. You have left out NASA.

Dr. HAWORTH. I don't believe NASA uses this system.

Dr. WILSON. NASA has some committees similar to our divisional committees but no committees at the panel level.

Dr. HAWORTH. All the agencies have advisory committees, but I am talking about the actual selection of proposals.

Mr. VIVIAN. You would say your agency and NIH use it heavily, DOD to a moderate extent, and AEC and NASA to a very slight extent?

Dr. HAWORTH. I don't know to what extent Defense uses it.

Mr. VIVIAN. Has there been any informal exchange between these agencies on this system to allow the people in charge to be relatively exposed to your procedure?

Dr. HAWORTH. They are all very aware of it. There certainly haven't been formal exchanges in recent times.

Mr. VIVIAN. Do you have any documentation to indicate why other agencies use it far less than you do?

Dr. HAWORTH. I haven't.

Mr. VIVIAN. Mr. Chairman, I would like to inquire into that subject further with the other agencies.

Mr. DADDARIO. There is no reason at all, Mr. Vivian, why we can't pose questions to them either in writing or when some of their representatives come here.

Mr. VIVIAN. As a basic matter in support of science in which all these agencies are dealing, I would like to know what their reactions are to this.

Mr. DADDARIO. We have a list of witnesses covering all the agencies.

Mr. CONABLE. Mr. Chairman, I understand NSF grants are considerably more prized than those from most other agencies, including the NIH. Is there any reason for this? Is it that your system carries with it a little more prestige?

Dr. HAWORTH. I think that what Mr. Vivian was talking about, the panel system and so forth, has created a feeling that the award of an NSF grant, or an NIH grant as far as that is concerned, indicates that the proposal was highly thought of by the scientist's own colleagues and this affects the man all right. I don't know of any other reason.

Mr. CONABLE. Why would there be any difference between NIH and NSF?

Dr. HAWORTH. I am not aware that there is.

Mr. CONABLE. I am simply repeating what people have said to me from my own college.

Dr. HAWORTH. I wouldn't know unless it is because we are able to fund a smaller fraction of proposals than NIH is.

Mr. DADDARIO. Dr. Haworth is happy to have the praise, anyway.

Dr. HAWORTH. At the same time, it is clear that we must initiate or accelerate movements designed to assist in the solution of several problems that the project grant technique used alone either does not help with or intensifies. First: Lack of flexibility at, say, the departmental level; it is difficult to support general, or centralized facilities and services such as shops, general-use computers, and special libraries. Second: some decrease of freedom of action of college and university administrators in determining the overall institutional pattern of development and growth; this pattern may be unduly influenced by the nature of programs finding most ready acceptance in Washington.

The institutional base grant was designed to partially offset these disadvantages. We believe that the scale of such grants should be increased and, in order to remove inequities to institutions receiving their primary support from other agencies, that a total Federal base should be used for determining grant amounts.

Since we first talked about it on Wednesday, I might digress to remind you what the institutional base grant is. Once a year we give a grant to each institution that has received research or research participation support from us in the form of project grants. This so-called institutional base grant is calculated using a formula which is based on the total amount of the institution's project grants.

For example, in the institutional base grant, the first $10,000 of NSF project grants is matched 100 percent, the next roughly a million dollars is matched 10 percent, and then down to 3 percent, and so forth, to a celling of $150,000. So these range from a few thousand dollars to $150,000, most of the money falling in the range of grants of a few tens of thousands of dollars.

The universities and colleges prize these funds very much, because they are able to fill in gaps, to do things that they couldn't do under the project system. This is partly because the project grants just don't cover some of these other needs, partly because to get a needed item for common use, machine tool or something of that sort, they would have to get several professors to pitch in from their own research projects and this is pretty hard to do. So these institutional

base grants have been, dollar for dollar, the schools all say, the most useful funds they have received because they are flexible. The grants are based on the level of our own research grants. No other agency has quite the same kind of program, although NIH has a similar one, especially in the professional schools. This gives rise to an inequity. For example, suppose that we supported a nuclear research group at university X using a Vander Graaff generator, and the AEC supported a nuclear research group using a similar machine at university Y. Then the university X would get an institutional base grant because their funds came from us, and university Y wouldn't because their funds came from AEC.

So we think we should make a transition, which will take some doing administratively, to basing our institutional grants on the totality of Federal funds at an institution rather than just on our own funds, in order that the happenstance of whether a university receives support from NSF rather than say, AEC, won't determine whether they get base grant funds or not. We would have to reconstruct the formula, of course, but that we can do.

We are also likely to continue to move toward more comprehensive research project grants that provide funds for coherent groups of related activities. In addition to the additional flexibility they allow, such larger grants have the important incidental advantage of reducing the administrative load on both the university and the Foundation.

A third problem is the concentration of research funds in a relatively small number of institutions. This is an undeniable fact. But it is equally true that this concentration of support results from the fact that those most capable of outstanding contributions to science and technology naturally gravitate to institutions which, over several decades, slowly accumulated notable faculties and excellent facilities. Federal support did not create this situation; indeed, to some extent it has already led to the accelerated building up of strong centers where there was only incipient strength a few years ago.

This leads me to a second question: How can we most effectively help build increased strength in institutions of higher education throughout all regions of the country?

In considering this matter we should bear in mind two related goals: First, we should try to assure continuous growth in the scientific capabilities of the country, which clearly means we must continue to improve the capabilities of our universities and colleges and, in particular, to increase the number of first-class institutions; second, in doing this we should try to make sure that all regions of the country come to have strong academic institutions.

We at the Foundation have given a great deal of thought to the problems posed by these two goals. We have recently identified four courses of action which should be followed in the effort to optimize academic science and science education throughout the country. These are not separate choices but part of a single, overall design; in part they represent a reaffirmation of longstanding views and policies, but they also offer special guidelines for the near-term future:

1. Outstanding quality should be maintained and even enhanced in those graduate institutions where it now exists. Excellence has no upper limit. Its existence invites challenge and competition as well as emulation, and it is not a self-perpetuating attribute, as the

history of some American universities demonstrates. As I pointed out Wednesday, such institutions are important national assets, because they are the leading sources of our scientific progress and their graduates are vital factors in energizing the entire national scientific structure, including the university and college community as a whole.

Our present programs are well adapted to serve their needs. The outstanding institutions—and the members of their faculties—can and do compete successfully for our project support and for facilities funds; they thereby qualify for—and thus receive—institutional base grants. They will continue to do so as long as we maintain programs that require competition on the basis of quality—as we must.

2. Increasing assistance should be granted to those graduate institutions which already possess recognized, though not necessarily outstanding research and educational competence, together with clear potentialities for effecting significant qualitative improvements. In recent decades a number of institutions have registered fairly rapid gains in quality—overall as well as in particular departments or fields. The number of such institutions with potential for development beyond mere competence, or with departmental "islands of strength" worth augmenting, is greater than is generally realized. Special efforts with proper timing are required if these promising situations are to be capitalized with a view toward enhancing the Nation's total capabilities for science and technology. The Foundation's science development program was established with these needs in mind. We intend to continue to exploit it in its present form. In addition, we are seeking to find ways to assist in building up and broadening "pockets of strength" in educational institutions whose present overall capabilities are not great enough for them to compete successfully for major science development grants.

3. Research funds should be made available to promising younger members of science and engineering faculties who have not yet achieved reputations and whose chances of securing Federal research support are understandably small, given the accepted and desirable criteria of proven merit and high quality. A young scientist located in a leading institution has opportunities to engage in meaningful research and win recognition through association with distinguished senior scientists who do enjoy support. Such opportunities are considerably less for young unknowns located at institutions which receive little Federal support for research or education. This group constitutes a research potential which the country should not ignore. Moreover, the roles of research and education are so interrelated that modest investments of research funds in these men will, at the same time, yield returns in better educational opportunities for the student bodies in such institutions. The Foundation is already experimenting with methods of assisting in this problem.

4. Assistance of appropriate kinds should be made available to help lift the general quality of undergraduate science education. Quantitative expansion of academic institutions to provide places for the stream of college-bound youth is not alone sufficient to enhance the capabilities of science. Also necessary is the provision of educational opportunities of sufficient quality to evoke and nurture the ability and talent contained in a burgeoning college population.

Failure in this regard would be at substantial cost to the Nation's future capabilities for science and technology. Additional assistance therefore should be given colleges, and the undergraduate components of the universities, for the development of improved curricula and teacher training, and for needed facilities, such as laboratories, equipment, and science libraries.

It is worth noting that at the suggestion of the Foundation these four courses of action have been adopted in principle by the Federal Council for Science and Technology as guidelines for the future: The first three for all the science supporting agencies—insofar as they are consistent with their respective missions and authorities—and the fourth for the Foundation.

Not only are these four courses of action directed at different needs of the academic community, but they also require different criteria for implementing them. In particular, it is essential that we continue to have both programs which stress present quality or merit as the primary criterion and programs that are pointed at the development of yet unrealized potential. We must be careful not to mix the two for it is essential in selecting proposals for support to use criteria that are appropriate to the objective sought—and these criteria differ from one objective to another. On the other hand thought should be given to sometimes combining different types of programs to achieve overall objectives, such as institutional strengthening. For example, in appropriate cases research grants and funds for facilities might be combined to support a particularly promising group.

In a different dimension, our assistance should be direct and with a minimum of redtape. We must avoid burdening good intentions and good work with a heavy bureaucratic load. The relations between the Federal Government and the Nation's universities and colleges must remain as flexible and simple as we can keep them. There has developed between the Government and the universities and colleges an intricate interdependence. This relation is delicate. It thrives when the requests the Government makes of educational institutions are consistent with their inherent goals. Everyone benefits by the simple act of strengthening those institutions. Everyone suffers when the Government imposes restraints, requirements, and restrictions which limit the academic or intellectual flexibility of the institutions. I am concerned that increasing Federal support has carried with it a tendency toward increased restraint. Simple examples are the increasing paper load in accounting for Federal grants-in-aid and the special conditions accompanying such grants. Because we, at the Foundation, have a special responsibility for the health of academic science, this concern weighs heavily upon us. It is my hope that the Foundation will develop simpler and less contraining techniques for the support of university and college programs; that is, techniques which return as fully as possible to the original spirit of the grant-in-aid.

Although these last few remarks were directed primarily toward programs in support of academic research, they are also applicable in large measure to our activities in support of science education. Let me now speak more specifically of our aspirations relative to this segment of our operational responsibility.

We must increase and strengthen our efforts to upgrade the quality of science education at all levels and in all fields. As time moves on,

we will be working even more closely with the universities and colleges in this endeavor. We have abundant evidence that this mode of operation is sound and effective.

In earlier comments I have dealt directly or indirectly with many of our hopes with respect to graduate and undergraduate education in the sciences. NSF will continue to deal with the qualitative and innovative side of such education. We will continue, possibly on a somewhat broader scale, to emphasize the value of research participation as an important auxiliary educational device at various educational levels. We hope to use our institutional support and facilities support activities more explicitly as elements in our approach to science education. And we will wish, of course, to continue and strengthen our fellowship and traineeship activities which have shown themselves so valuable.

As you know, we have been able to make a real impact on improving the subject matter education of teachers of science who are already teaching. We are now searching for ways of making sure that later generations of such teachers are well-prepared when they begin their careers. Our commitment to the achievement of this goal is greater than our understanding good ways of reaching it, but experiments already initiated may help us accomplish some of our hopes within the next few years.

We have, by virtue of our excellent rapport with the scientific community, succeeded in substantially increasing the number of scientists of competence engaged in activities for the improvement of science education at the precollege level. This has proven to be a most effective means of creating new interest in the qualitative improvement of courses of study, in teacher preparatory programs, and in the development of special opportunities for highly able and strongly motivated young men and women. Elementary and secondary school teachers, moreover, have been revitalized by the knowledge that there are indeed university and college faculty members who are interested in the subject matter of science at the precollege levels. Continued emphasis along these lines is called for, both to assure further qualitative improvements in science and mathematics instruction in our schools, and to insure effective use of the abundant and unique resources available for such purposes in our institutions of higher education.

Although our relations with the Office of Education are now quite close, they will become even closer. We will also maintain and strengthen our ties with all the other groups, private and public, that support programs in science education.

More generally, as time moves on, I see NSF assuming a more active role of leadership. Its traditional role has been an essentially receptive one—one which leads us to react to and support, to the extent we can, meritorious ideas of active scientists. Such a role may be described as one of enlightened opportunism. Thus we stand ready to receive and support good ideas, but only in a limited number of cases do we initiate activities.

In certain areas, our role must be a more active one. We must be more active in the promotion of, as distinguished from the support of, basic research. We must intensify our leadership role in our assigned responsibilities in the fields of weather modification and science information. There are whole classes of other problems in the national

interest which can benefit from concerted and directed initiative and leadership by NSF in fulfilling its responsibilities. Here I am thinking of problems in the engineering and social sciences as well as the biological and physical sciences—and, especially, of problems that can be dealt with only by teams of research workers drawn from two or more fields.

Mr. VIVIAN. Do you have a list of those areas in which you feel we should take a more active role in promotion rather than support?

Dr. HAWORTH. I think we should concern ourselves a good deal more than we have with some of the scientific and engineering—and I include the social sciences here—problems that underlie some of the social problems such as transportation, urbanization, and many things of that sort. These are not areas where proposals are stimulated simply by a receptive attitude, for two reasons. First, most scientists and engineers in the universities have not been very actively involved in these areas, and, secondly, these problems are not the kind that one individual can really attack very well. So the individual method of approach which has primarily characterized our research programs is not really effective for this broader kind of problem. What I am trying to say is that we have to think how we can encourage concerted attacks by people in more than one discipline or more than one institution on some of these broader problems. I have to confess it is still fairly vague in my mind, but something needs to be done about these things.

Mr. VIVIAN. I have the same interest and concern, but unfortunately it is also vague in my mind. I was hoping it was more solidly established.

Dr. HAWORTH. Some of the staff I am sure could talk more specifically than I if you would like to take the time.

Mr. DADDARIO. Not right now, Doctor.

Dr. HAWORTH. I have said this earlier, but I think it is worth repeating here and making it more explicit. The Foundation, over the years, has developed a number of programs to serve a variety of purposes. Some of these are further along than others. We are now at the stage where we can begin to round out our activities, to strengthen some programs, and to exploit others even more fully. The years before have been years of growth and program experimentation. We are now consolidating our gains. The years to come will be years of increasing fulfillment. But we must not stop the evolutionary process—for science is indeed an endless frontier and we must adapt ourselves to its ever-changing pattern.

In such endeavors the Foundation should take full advantage of the wide latitude accorded it by the Congress in the National Science Foundation Act. We have found this statute to be a remarkable and flexible legislative mandate, one which has made possible the timely introduction of new and novel mechanisms for coping with a variety of problems, both in research and in science education. As we survey the past policies and procedures of the Foundation, however, we recognize several areas in which there exists authorization over and above that which we have fully utilized heretofore. I believe that we can use these additional elements of our authority in ways which are beneficial to the Nation.

I have in mind much the same sort of thing as I had in answer to Mr. Vivian's question.

In closing, Mr. Chairman, I should like to pay sincere tribute. I believe it can be fairly said that the National Science Foundation has been successful; that it has come to be a vital force in the advance of science in this country; that its future augurs well. Its success results from many factors. It was conceived by brilliant men; it was established and has been supported by an enlightened Congress; it has been encouraged and inspired by four successive Presidents; it has been ably led by the National Science Board, Dr. Waterman and others. All this is widely recognized. What has not been so apparent to the world at large is the vital contribution of the members of its able, dedicated, and self-effacing staff. Without their effective efforts, all the wisdom, all the leadership could have led to naught. It is a privilege and a pleasure to be associated with them.

Thank you, Mr. Chairman.

Mr. DADDARIO. Dr. Haworth, I want to thank you for your 3 days of testimony. It has been extremely helpful to the committee. Your closing statement includes a great deal that we should all think about very carefully.

If there is no objection, we have some questions that we will send to you to be answered for the record, and we would like to have this done prior to the time you return at the close of the hearings. All of the members will have an opportunity, if they have any specific questions they would like to have answered, to submit them in writing.[1]

I would also like to thank your staff for being here and for helping to prepare this presentation. It has been a very helpful contribution, and a good foundation for the hearings which will continue through the month of July and through the first week of August.

We will be in touch with you, of course, from time to time, Dr. Haworth, as questions arise which we think we ought to talk to you about.

Thank you.

This committee will adjourn until next Tuesday morning at 10 o'clock at the same place.

(Whereupon, at 12:05 p.m., the hearing was adjourned until Tuesday, June 29, 1965, at 10 a.m.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

TUESDAY, JUNE 29, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order. Our witness this morning is Dr. Donald F. Hornig, who is the Director of the Office of Science and Technology.

Dr. Hornig, we are pleased to have you here this morning.

STATEMENT OF DR. DONALD F. HORNIG, DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY

Dr. HORNIG. Mr. Chairman and members of the subcommittee, it is a pleasure to be here. I am very happy to have the opportunity to appear before the subcommittee in connection with its comprehensive review of the National Science Foundation.

As indicated in your invitation to appear, Mr. Chairman, I will direct my remarks largely to the relationships between the Office of Science and Technology and the National Science Foundation, with some remarks on the Foundation's overall program.

The subcommittee has just completed 3 days of hearings with the Director of the National Science Foundation. You also have a detailed background report on the National Science Foundation prepared by the Science Policy Research Division of the Library of Congress. On the basis of your hearings and the background information available to the subcommittee, I believe it is unnecessary for me to recite—so I will merely underscore—the brilliant record that has been achieved by the National Science Foundation in strengthening American science and science education. Its programs have measured up to and have come to symbolize the highest standards of excellence. Its policies and practices have been characterized by imagination and creativity in forging relations between the Government and our educational institutions that have been of unquestionable benefit to both.

In framing the Foundation's basic legislation in 1950, the Congress wisely foresaw the need for developing and encouraging the pursuit of a national policy for the promotion of basic research and education in the sciences, and so charged the National Science Foundation. It also directed the Foundation to support basic research and education in the sciences to strengthen the Nation's scientific research potential.

In both its policy role and in its mission to strengthen American science per se, the Foundation was given a unique charter among the Federal agencies. However, the Congress did not appreciate the difficulties inherent in giving the Foundation a broad policymaking role, nor were its modest budgets sufficient for it to strongly influence the overall rate of scientific progress.

The Foundation is a coequal member of the sizable family of Federal R. & D. agencies and a small brother at that, representing some 14 percent of the total Federal support of academic research in fiscal year 1965. Given the Foundation's coordinate position in the governmental hierarchy, it could not be expected that the Foundation would be vigorous in developing national science policies for there was no means for inducing other Government agencies to follow suit short of the extraordinary device of Presidential direction.

A similar problem confronted the Foundation in carrying out its 1950 statutory directive to evaluate the scientific programs undertaken by other agencies of the Government. The bulk of federally financed research is financed by agencies with applied missions—in defense, space, atomic energy, health, etc. The Foundation's budget for fiscal year 1965 accounted for only 4 percent of the total Federal obligations for research. The amount and character of research required by a given agency to carry out its statutory responsibilities must be judged in relation to the overall programs and goals of the agency as well as to the programs of all other agencies. The Science Foundation could not be expected to evaluate the merits of research programs in relation to the statutory missions of other agencies. A unilateral attempt to do so would have inevitably impaired the external relationships of the Foundation and imperiled its own programs.

I have mentioned the difficulties inherent in giving the Foundation a broad policymaking and evaluating role. At the same time, I would like to emphasize the positive and highly constructive influence that has been exerted on the total Federal science effort through the Foundation's own policies and sponsored research at academic institutions, well in excess of its proportion of the Federal research budget.

The establishment of the National Science Foundation was one of a series of steps in the long history of evolution of science organization in the Federal Government. The evolution since World War II was accelerated both in terms of the number of agencies having major R. & D. activities and in the Federal investment in research and development. The next significant step in the evolving science structure took a different turn. In the mid-1950's the rapidly expanding research and development activities of the many Federal agencies and the growing potential of science and technology to contribute to the Government's programs and policies gave rise to increasing concern over the lack of central consideration of the many ways in which science and technology interact within the governmental structure. It was finally recognized that a major organizational innovation was required, and that the functions of central coordination and policy formulation for research and development could be carried out only at the highest level of Government—in the Office of the President. It was further recognized that Presidential leadership for this purpose required special staff support.

Immediately following the Soviet sputnik in the fall or 1957, the first special assistant to the President for science and technology was appointed to provide full-time staff to the President in dealing with matters pertaining to science and technology. At the same time, the President's Science Advisory Committee was reconstituted as a White House committee to make directly available to the President the considered views of 17 eminently qualified scientists and engineers from outside of Government; and through that committee and its panels, to make available to the President the views of experts from anywhere in the United States on special topics as they arise.

Mr. DADDARIO. Dr. Hornig, could we have for the record the present membership of the President's Science Advisory Committee?

Dr. HORNIG. Certainly.

(The information requested is as follows:)

PRESIDENT'S SCIENCE ADVISORY COMMITTEE—MEMBERS AND CONSULTANTS

Chairman: Dr. Donald F. Hornig, special assistant to the President for science and technology, the White House, Washington, D.C.

Vice Chairman: Dr. Herbert F. York, Jr., professor of physics, University of California at San Diego, La Jolla, Calif.

MEMBERS

Dr. Lewis M. Branscomb, Chairman, Joint Institute for Laboratory Astrophysics, Boulder, Colo.

Dr. Melvin Calvin, professor of chemistry, University of California, Berkeley, Calif.

Dr. Richard L. Garwin, IBM Watson Laboratory, Columbia University, New York, N.Y.

Dr. Marvin L. Goldberger, professor of physics Palmer Physical Laboratory, Princeton University, Princeton, N.J.

Dr. Philip Handler, chairman, Department of Biochemistry, Duke University Medical Center, Durham, N.C.

Dr. Franklin A. Long, vice president for research and advanced studies, Cornell University, Ithaca, N.Y.

Dr. Gordon J. F. MacDonald, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Calif.

Dr. William D. McElroy, chairman, Department of Biology, the Johns Hopkins University, Baltimore, Md.

Dr. George Pake, provost, Washington University, St. Louis, Mo.

Dr. John R. Pierce, executive director, Research Communications Principles and Communications System Division, Bell Telephone Laboratories, Murray Hill, N.J.

Dr. Kenneth Pitzer, president, Rice University, Houston, Tex.

Dr. Edward M. Purcell, professor of physics, Harvard University, Cambridge, Mass.

Dr. Frederick Seitz, president, National Academy of Sciences, Washington, D.C.

CONSULTANTS-AT-LARGE

Dr. Detlev W. Bronk, president, the Rockefeller Institute, New York, N.Y.

Dr. Harvey Brooks, dean, Division of Engineering and Applied Physics, Harvard University, Cambridge, Mass.

Dr. James B. Fisk, president, Bell Telephone Laboratories, Murray Hill, N.J.

Dr. James R. Killian, Jr., Chairman of the Corporation, Massachusetts Institute of Technology, Cambridge, Mass.

Dr. George B. Kistiakowsky, professor of chemistry, Harvard University, Cambridge, Mass.

Dr. Edwin H. Land, president, Polaroid Corp., Cambridge, Mass.

Dr. Colin M. MacLeod, Deputy Director, Office of Science and Technology, Washington, D.C.

Dr. Emanuel R. Piore, vice president and chief scientist, International Business Machines Corp., Armonk, N.Y.
Dr. Isidor I. Rabi, professor of physics, Columbia University, New York, N.Y.
Dr. Jerome B. Wiesner, dean of science, Massachusetts Institute of Technology, Cambridge, Mass.
Executive Officer: David Beckler, Office of Science and Technology, Washington, D.C.

One of the first studies undertaken by the President's Science Advisory Committee was an examination of measures required to strengthen American science, with special emphasis on the role of the Government. The Committee's report recommended the creation of the Federal Council for Science and Technology having as a principal function the provision of more effective planning and administration for Federal scientific and technological programs affecting more than one Federal agency. Sitting on the Federal Council for Science and Technology are policy-level officials from each of the major R & D agencies. This body continues today to be an indispensable forum for consideration of interagency problems and for focusing multiple-agency viewpoints in the development of common policies for the administration of agency research and development programs. The special assistant to the President has chaired both the Federal Council and the President's Science Advisory Committee from their inception, providing a vital coupling between these Committees and the concerns, needs, and actions of the President.

The concept and operation of the Office of the Special Assistant to the President for Science and Technology proved so useful to the President, to the other offices of the Executive Office of the President, and to the agencies themselves that the Office of Science and Technology was established in the Executive Office of the President by Reorganization Plan No. 2 submitted to the Congress by President Kennedy in 1962.

Its main purpose was to provide the President with permanent staff resources to assist him in developing policies and evaluating programs with the general objective of assuring that science and technology are used most effectively in the national interests. It was also aimed at providing more effective communication with the Congress on Government-wide policies and programs in science and technology. The Director of the Office of Science and Technology continues to serve in the role of special assistant to the President. The small staff of the Office provides support for the activities of the Science Advisory Committee, the Federal Council, and their numerous working groups and panels.

Mr. DADDARIO. Dr. Hornig, could you give us some examples of the way in which this is worked out? I am referring to your statement:

> It was also aimed at providing more effective communication with the Congress * * *.

In what ways has this proven to be effective?

Dr. HORNIG. Of course, my appearance here this morning is one example of such communication. I haven't kept an exact count, but I think I have testified before various committees roughly a dozen times this spring. In addition, we have published and sent to the Congress reports on the national program on oceanography, on water resources, and on atmospheric sciences. These are examples.

Mr. DADDARIO. Up until 1962, OST published annual reports of the work of Federal Council. Was there any particular reason this was discontinued?

Dr. HORNIG. I am not quite sure I know to what you refer.

Mr. DADDARIO. Annual reports of the activities of the Federal Council for Science and Technology were published up to 1962. I have seen some of these and have found them quite helpful. I just wonder why they have been discontinued.

Dr. HORNIG. I do not know how to answer that question except to say we are preparing one now for 1963 and 1964 because we thought one ought to be available. We will issue it shortly.

Mr. BROWN. Mr. Chairman.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Could I inquire further into the method of operation of the Federal Council? Does this have regular meetings? Does it engage in any activities other than talk amongst itself? Not that that isn't an important activity, but I am trying to visualize just how it functions.

Dr. HORNIG. The Federal Council does meet regularly; yes. It meets every month. It also accomplishes most of its work through a series of panels in those areas in which many agencies are engaged. For instance, the Interagency Committee on Oceanography is a member of the Federal Council; so is the Interagency Committee on Atmospheric Sciences; also, there is a Committee on Scientific and Technical Information. In these fields in which many agencies are engaged, the committees to the Council do much more than talk. They actually attempt to coordinate the programs, and they assemble for the Council information on both the content and the budgets of the total programs.

In oceanography the Interagency Committee has helped with such problems as ship scheduling to be sure that if agency A is sailing a ship for its purposes that this is known to agency B so it could send people along if it is interested in doing research in the same areas of the oceans, for example.

In the case of the Committee on Scientific and Technical Information it has been engaged in a very intensive interagency study of a national approach to the dissemination and free flow of scientific information and the utilization of the most modern technology for the purpose. This has been a planning function that it is engaged in.

The Council, itself, of course, was set up by Executive order, and its original role was to provide advice and assistance to the President. It in fact has gone beyond that role because in the course of talking, as you say, and exchanging information on agency practices, it found that although it is not in itself an action or direction group, through consensus it could achieve common actions by the agencies simply by comparing notes and deciding in effect that there was no reason to do things differently.

Mr. BROWN. This is the sort of thing I was interested in, whether they are seeking to solve some of these problems that cut across a number of areas. The one that you mentioned—the dissemination of scientific information—this is a problem which is of great relevance to the scientific community. Many agencies have different systems for collecting and disseminating this information, and it would be desirable if a certain uniformity could be achieved.

Dr. HORNIG. I liken what the Council is doing in this area through the Committee on Scientific and Technical Information to the role of the Bell System many years ago of tying together many of the telephone companies throughout the United States in a planning and staff way so that it is possible to dial San Francisco going through seven telephone companies without you as the consumer knowing that seven existed. I think we would like to be in the same position with respect to information. We have the local information systems—those of Department of Defense, NASA, and AEC for example—but when you look for information in the future you would not as a user have to concern yourself with where it happens to reside. I hope we can tie these together so, like dialing, you can find your way to whatever you want to know wherever it resides.

Mr. MILLER. Mr. Chairman, I think the problem is one which is not at all simple, and one in which the executive department bears only half of the burden; the other part must be accepted by Congress.

We have grown up with these things. Science is spread throughout the gamut of committees of Congress. When you try to tie areas of science together, the interdisciplinary fields, you find one committee having jurisdiction over one facet of the problem, and another committee having jurisdiction over another. It is something that the Congress has to work out, not the executive department.

I think Dr. Hornig cited the case of oceanography. You will find oceanography having its roots in about seven different committees in the House. They are all jealous of their powers and authority, and no committee wants to give up any of its power. The result is we have had numerous bills trying to solve this problem. Perhaps there is not a more important facet of study that we have to deal with than oceanography; yet, you cannot look to any one place to get it, and the overlapping is great. So, we try to solve it by setting up an interdisciplinary or an interagency committee, but these have never worked out too well, not only in this field but in any field. If it had not been that the President and Mr. McCormack were interested in space in the early days and set up this committee that evolved NASA, space would find itself in the same position as oceangraphy, with no one to plead its cause.

I believe that we in Congress have a responsibility, and we have to accept it. It is not going to be easy anymore than it is with our jurisdiction over NASA. We find few jurisdictional disputes. We have been able to resolve them all right, and we hope we continue in the future to do so. I just want Dr. Hornig to know that at least some of us appreciate the position he is in, and I know he appreciates the position that we are in. It is a challenge to all of us in the field of science to try to bring some order out of chaos.

Dr. HORNIG. If I may interrupt my testimony, I would like to comment on two aspects of the very wise remarks that the chairman has made. It presents difficulties for both the Congress and for the executive; this division has its roots in part in the nature of science. You might use oceanography as an example. One can, on the one hand, talk about a national program in oceanography. On the other, it is also perfectly true that with respect to those elements of oceanography that are concerned, for instance, with the operations of the Navy, whether or not there were a national program in oceanography, the

magnitude of our effort would be determined by our national defense needs. As a matter of fact, even in the presence of a national program, this is one segment of the activities whose scale is decided not by what one thinks about oceanography, but what the Navy needs from oceanography. And similarly the effort in fisheries resources, for example, is tied in part to what we expect from the ocean and fishes. Of course, in pursuing these separate goals people sometimes do the same thing. That is why we try to assemble a program. I don't think there ever will be a perfect administrative solution either in the executive or in the division of responsibilities among congressional committees.

Mr. MILLER. Democracy, Doctor, is not a dead thing. You never fully accomplish it. It is as alive as the people who form the government, and so long as this is true, there are going to be changes taking place. We are always going to be confronted, I think, with the problem we have today.

Dr. HORNIG. I think that is very true. In fact the vitality and freshness of the viewpoint we have, by having people look at problems from several different points of view, probably far outweigh the loss of administrative neatness that we may have.

Mr. DADDARIO. Yet, Dr. Hornig, the changes which have taken place in the National Science Foundation since it was founded, and the transfer of some of its functions to your office came about because we wanted to have different points of view, but not too many. You have to keep some order to it, and this is what we are really talking about.

Dr. HORNIG. I think that is correct. To say that one wants diversity does not mean that one wants chaos. I think that is true in both the Congress and the executive. I will touch a little bit more on that in my prepared testimony, if I may continue.

In recognition that the development of science policies affecting several agencies and evaluating agency programs can only be performed at a higher level. Reorganization Plan No. 2 was based on a transfer of two functions from the National Science Foundation to the Office of Science and Technology. First, it split the function of developing and encouraging the pursuit of a national policy for the promotion of basic research and education in the sciences by transferring to the Office of Science and Technology as much of that function as would enable the Director of the Office to advise and assist the President in achieving coordinated Federal policies for these purposes. The National Science Foundation retained the balance of the authority, including explicit responsibility for developing policies to govern NSF programs for the promotion of basic research and science education.

The reorganization plan also transferred to the OST the 1950 function of the National Science Foundation to evaluate scientific research programs undertaken by other agencies of the Federal Government. It left in the Foundation statutory responsibility for correlating its scientific research programs with those undertaken by individuals and by public and private research groups.

Mr. DADDARIO. Could you give us some examples of the way in which OST has evaluated scientific research programs after this function was transferred to it from the National Science Foundation?

Dr. HORNIG. I suppose the most explicit recent example I can cite is the report of the Wooldridge Committee. The exact title is "Bio-

medical Science and Its Administration: A Study of the National Institutes of Health." This is a study in depth of the quality of the NIH programs and of their administration. This report was published this last spring, as you may remember.

Mr. DADDARIO. To whom do you make your recommendations? How does it come out with a report and translate that into action?

Dr. HORNIG. Of course, the whole mechanism is set up essentially to advise and assist the President; so, putting results into effect consists of a process of in many cases talking to individuals, and sometimes it translates itself into legislative programs which the administration submits to the Congress.

Mr. DADDARIO. Do you see this as a mechanism through which OST can in fact sharpen the objectives and achieve better purposes so far as national goals and objectives are concerned? Does this appear to you to be a way in which we can make better choices and establish better science policy in the future?

Dr. HORNIG. What I would like to make clear in this goal is that OST is a very small organization so that we cannot and do not attempt to perform this evaluation function in detail by looking over the shoulders of agencies in the ordinary performance of their performance of their missions. OST has had to confine its efforts, and I think this is a good thing, to what we call major policies and programs. With respect to the question you asked——

Mr. DADDARIO. If you could just follow that up a moment, you have already stated that the National Science Foundation could not in fact look over the shoulders of other agencies. Since this function was transferred to your office and since you do have the opportunity to look over the shoulders of other agencies, are you somewhat restricted in doing so by choice or because of a limited number of staff personnel? If that is so, should that be changed; do you have any recommendations in that regard?

Dr. HORNIG. I think it must be said that we are still feeling our way as to what is best. We have a horror of becoming a new bureaucracy with little fingers in every part of the Government. I have not myself felt very sanguine about having a super-White House structure which would try to interfere in an operational way with the functions of the agencies.

I think our limitation, nevertheless, has been in the size of the staff. This year, for example, we have requested of the Congress an enlargement of the staff by four members. That isn't drastic, but that is about 25 percent, which I think in 1 year is about the right rate of going ahead. At least in the House, favorable action has not occurred.

I think it is true in the sense that the chairman mentioned that the committee method of looking at things is excellent for collecting information; it is not a good way to provide leadership for action. That rarely comes from interagency committees. For that purpose I think we do need a somewhat larger staff and organization than we have now. We are trying to look ahead in this goal-setting.

We are running this summer a big summer study under the chairmanship of Dr. Brooks, who is in the back of this room. By big I mean 15 men devoting 6 weeks of their time, but they are all topnotch people. This summer study is going to try to lay down some

rational guidelines for academic research and for its growth, and these questions of how you choose among field support and how you relate the efforts of the many agencies that are involved.

So, we are trying, I think, to the limits of our staff capacity and also our ability to really comprehend the problems, to set out more rational goals, policies, and guidelines for the total Federal program.

Mr. DADDARIO. Then, in a sense, Dr. Hornig, you intend to build up your staff capability. It would seem to me that you should do this, taking into consideration the support functions that you provide for the Science Advisory Committee, the Federal Council, and all the other working groups and panels. But once you say that and bring out the program you have with this group under the leadership of Dr. Harvey Brooks, in whom we do have great faith, you are in fact looking over the shoulders of these agencies. It is your intention to bring some order and direction from your office into the very functions of these agencies. What direction, then, does that bring you to, and what is the National Science Foundation's function in this process?

Dr. HORNIG. Of course, there is some interaction among the individual agencies. Our goal, if you like, is to act to some extent as 1 government and not 20 autonomous governments, so that when the policies of individual agencies interact with the policies of other agencies, then we should be involved.

Now, as to the National Science Foundation, it is, of course, the only agency which has as a fundamental responsibility the health of basic American science and of science education. I think, myself, that its role ought to expand relatively. As you know, the budget we submitted this year moved in precisely that direction. This may be an example of our activities.

We looked over the plans of all of the agencies for the support of academic research. We looked at the projected growth of student enrollments for the coming year and the probable increases in the costs of educating them and allowing them to carry on research and concluded that something like a 15-percent increase in the total national program in basic research in the universities was desirable for this year.

Then, the second decision was, because of the Science Foundation's particular responsibilities in this area, that this 15-percent growth should be concentrated, not exclusively, in the Science Foundation. The budget funds were requested for an increase of very nearly 50 percent in the Science Foundation portion of the budget for the support of basic research in universities. At the present time it doesn't look as if we will obtain that from the Congress. This has the effect that we are not going to be supporting university science students as well next year as this year because the growth in student population is one of the inexorable things that we are living with.

Mr. DADDARIO. You foresee, then, that in the event the Congress does not appropriate the funds in the amounts requested, that there will not be within the National Science Foundation the flexibility to transfer funds in order to achieve this particular purpose. This seems to me to be an important function, and perhaps more important than the allocation of its funds for other programs.

Dr. HORNIG. Its other programs are very important, too. Of course, in the action it was instructed not to cut its appropriation for the science development program or for its high school teacher programs at all. In fact, it was instructed to spend a little bit more on

the high school teaching program in the House action than it had budgeted. So, in its flexibility to reallocate funds it has in fact been constrained. Of course, it is left with some flexibility.

Mr. YEAGER. In connection with your statement that the OST function is to evaluate scientific research programs undertaken by agencies of the Federal Government, would it be a fair statement to say, in effect, that there is some evaluation here by recommendations that you make in connection with the annual budget process?

Dr. HORNIG. Yes, indeed.

Mr. YEAGER. Would this be as part of OST's function or the Federal Council's function, or both?

Dr. HORNIG. This is primarily an OST function, but the OST in this sense acts as a funnel for utilizing all of the sources of information and advice that are available to it. In this sense the Council, of course, is one of the principal information inputs.

Mr. DADDARIO. Please proceed, Doctor.

Dr. HORNIG. This logical realinement of functions has enabled the National Science Foundation to participate more effectively in the science policymaking process and to develop stronger programs of support than would have been the case were there no Office of Science and Technology. The Foundation continues to have full intellectual responsibility to examine, make policy recommendations, and take actions with regard to enhancing the health of American science which, as I previously indicated, is a unique responsibility of the Foundation.

The Office of Science and Technology provides a means to secure action on matters arising from the Foundation's activities that impinge on other agencies. It also permits the Foundation to take the lead, when requested by the Office of Science and Technology in organizing and carrying out interagency studies and evaluations. While the Office of Science and Technology looks to the Foundation for assistance in the broad areas of NSF responsibility for dealing with science as a whole, it has not interfered with the Foundation's internal operations and programs.

In consideration of these shifts in responsibility, I will discuss the relationships of the National Science Foundation to the science structure in the Executive Office of the President in two categories.

First, there are the special relationships between these two organizations that depend on the unique functions and capabilities of the Foundation:

1. The Science Foundation serves a central function for the Nation as well as for the Government in providing basic data on science resources and on the nature of Federal R. & D. expenditures, for example, through its Federal funds for science series and special analyses of Federal R. & D. expenditures. The data acquisition and analysis capabilities of Science Foundation are utilized by the Office of Science and Technology to provide a basis for the development of national science policies.

We see a need to supplement this excellent statistical series with more special analyses of problem areas in the support of science and science education. Such subjects as undergraduate science education, the use of postdoctoral students in research, geographical distribution of research support, and facilities for research would seem to offer

rich opportunities for analyses and assessments with policy and program implications. The conduct of such special area studies will in turn provide guidance for the gathering of statistics.

I will interject here the problem in all statistics gathering exercises is to make them coherent and to know what you are gathering statistics for, otherwise it is possible to expand them indefinitely and not to have them focus.

Mr. DADDARIO. In regard to the problem of keeping statistics up to date and their effectiveness if they are not up to date, the National Science Foundation put out a report in 1964 called "Industrial Research and Development Funds." In reference to it an article in Industrial Research Magazine said, and I quote:

> The rapid growth of research in industry makes the 1958 statistics appear ridiculous.

These were the 1958 statistics used in the NSF report of 1964.

Dr. HORNIG. One would like to have one's statistics current. One would also like to have statistics reliable. And these two objectives, not just in the Science Foundation, often conflict. One can get rough and ready figures ready, but detailed and solid figures often take a long time to check out. I wish there were slightly more current figures particularly on the industrial R. & D. side.

Mr. DADDARIO. Is there any reason why we could not have more reliable and more current statistics? You say you wish there were more up-to-date statistics on industrial R. & D. That being the case, if it would be helpful, why can't we have them, and how far back ought we to go?

Dr. HORNIG. Dr. Haworth could probably answer that better than I can, but I see no reason why we can't have more faster if we enlarge the effort and spend more money doing it. I mean more statistics collection, analyses and organization takes more people and more effort. There is always a question here, just as in the Bureau of Labor Statistics or anywhere else, how much you want to plague the world with questionnaires and data gathering. There is a question of balancing the value of the statistics gathered and the nuisance value of collecting them.

Mr. DADDARIO. If it is a plague, it ought to be a mordant one. It is important for this committee to take into consideration what recommendations and advice we get from you and other witnesses. Is this one place where in fact a greater effort ought to be made? Is it of such importance to the issuance of reports and the reliability which we can levy on those reports, that we ought to provide the National Science Foundation with the tools so that statistics can be as current and reliable as possible?

Dr. HORNIG. I think so, but I would add still that we conducted a considerable effort about a year ago through the Federal Council's long-range planning committee on trying to look ahead and to ask what information we needed to do a little forward planning. Now, it was quite clear the base is inadequate, and this would concur with what you have said. On the other hand, the hardest problem turned out to be to define clearly what statistics you really wanted, what statistics were really worth the effort, so the effort must not only be expanded, I think it should, but we are going to have to continue to

work and focus on what are the statistics that are really useful in an operational sense to the Government.

Mr. DADDARIO. New sampling techniques and this kind of thing?

Dr. HORNIG. Yes.

Mr. ROUSH. Dr. Hornig, in your opinion, is the National Science Foundation using the most modern, up-to-date equipment and techniques in this matter of gathering statistics?

Dr. HORNIG. I think the Science Foundation has done an excellent job. I think they have at times been a little slow, but as far as I can see they are doing an excellent job in collecting the statistics. Of course, they rely for many of the statistics on other organizations, both in the collection of internal Government statistics, where they rely on other agencies, and particularly when they go to the outside they rely on external data from industry, for example, so it isn't entirely within their control.

Mr. ROUSH. Has the Congress provided them with all the tools they need in this regard, or have they been denied certain tools?

Dr. HORNIG. I think this is a question Dr. Haworth would have to answer.

Mr. DADDARIO. Would you continue, please?

Dr. HORNIG. 2. The Science Foundation can serve either as an executive agent or a delegated agent of the Office of Science and Technology in taking the lead in connection with certain programs of broad importance. For example, the Science Foundation, at the request of the Office of Science and Technology, developed an interagency assessment of and reaction to the report of the National Academy of Sciences on needs in ground-based astronomy.

In the scientific and technical information area, the OST looks to the Science Foundation to provide leadership in effecting cooperation and coordination among non-Federal scientific and technical information services and organizations, and in developing adequate relationships between Federal and non-Federal scientific information activities.

The Science Foundation has provided support for a series of surveys by the National Academy of Sciences of research opportunities and needs in various fields of science, including chemistry, physics, and the use of computers in universities. This source of recommendations to the Federal Government has proved invaluable in the planning of Federal science programs.

3. The Foundation is a particularly valuable source of advice to the Office of Science and Technology on science policies that merit consideration for Government-wide application. Because of its broad charter, the Foundation, in planning its own programs, must necessarily take into account the science and science education activities of other governmental as well as private agencies.

The National Science Board has in recent times intensified its activities in developing policies for the Science Foundation, and we in the Executive Office regard this as a significant development that should lead to better understanding and to policies for guiding Federal science activities broadly. The actual formulation of Government-wide policies is normally undertaken through the Federal Council for Science and Technology or by the Office of Science and Technology in direct consultation with interested agencies.

4. The Science Foundation, with the support of the Office of Science and Technology, has increasingly taken into consideration the extent and character of the programs of other Federal agencies in the support of research at academic institutions. So that academic institutions supported by several agencies can take more initiative in their own science development and correct weaknesses that may arise or are not dealt with through agency research support, the Foundation expects to broaden the base of its institutional grant program to take account of the total Federal support of research at a given academic institution.

What I am referring to here is in the past the National Science Foundation institutional grants have used as their base the National Science Foundation expenditures at a given institution. They expect, beginning next year, to use as the base the total Federal Government expenditure.

As the result of an OST-Bureau of the Budget assessment of the needs and plans of all Federal agencies for the support of academic research in fiscal year 1966, it was found that a very substantial increase in the academic research support by the National Science Foundation would be required as the graduate student body and science faculties grow.

Mr. DADDARIO. Dr. Hornig, why would that be an OST-Bureau of the Budget assessment rather than a report submitted to your office or the Office of the President by NSF itself?

Dr. HORNIG. I think the problem last year was largely a practical one—the ability of any one agency's participating intimately in the planning of the other agencies and in order to be aware of their budgetary situation. Formal reporting procedures during the budgetmaking process get pretty slow. Although the budget is put together beginning in the spring, intensive activity really occurs from September to December.

Mr. DADDARIO. Yes, but should it begin with the Bureau of the Budget or with NSF? Should NSF make its own evaluation as to what it ought to do insofar as this particular subject is concerned? Then perhaps have your office and the Bureau of the Budget come to some decisions among themselves about it, especially in view of the fact that the NSF does have this responsibility? The Reorganization Act has transferred some of NSF's jurisdiction to you, but not this, as I see it.

Dr. HORNIG. Well, the problem looks like this. The NSF support is about 14 percent of the academic research budget; it is only 4 percent of the total research budget. It is exceeded in its contribution to universities by both the National Institutes of Health and the Department of Defense. Both the AEC and NASA support about half as much as NSF. So the question of what is proper and wise for NSF to support is very intimately tied to the plans of the Department of Defense and the National Institutes of Health. The National Science Foundation should quite properly provide advice as to what is required in the way of basic research for the country. But in translating this into budgetary terms, it is very sensitive to what the other agencies do, and it cannot know that until after preliminary budget decisions have been made. The problem to which we have begun to

make a successful approach is to try to know toward the end of the budget review how the totality is going to look for the next year.

Mr. DADDARIO. Then, I would assume that OST and the Bureau of the Budget could decide how much ought to be performed in each of the agencies. The direction, then, would come from OST and the Bureau of the Budget, and it would not necessarily have anything to do with the objectives of each of those agencies. There may be violent disagreement which the Congress might never know anything about. I don't put that out in a critical way but just as a supposition.

Dr. HORNIG. This is really the problem to which the chairman alluded earlier, both in connection with the Congress and the Executive. All of these programs have to be looked at from several points of view, both as part of a continued science program and also in relation to the objectives of the agencies individually. All but the NSF have other objectives than simply the health of academic research.

Mr. DADDARIO. Of course, we recognize that these problems exist. Yet, as we work closer and closer together, the situation should get better rather than worse. It seems to me that the National Science Foundation should make its needs and plans known so that there can be some review of these, and appropriate recommendations made about them in consideration of the problems involved in allocating funds to all of the agencies. This would appear better to me, rather than to have it appear, as it does here, that the OST and the Bureau of the Budget just figure out what is available, and carve it up and put it into slots, instead of making a determination of what is best for each agency.

Dr. HORNIG. Perhaps I should explain this a little bit further. This was not a carving up exercise. As we faced the budget last year, we began to worry as to what the effect would be on the NSF and on all of the other agencies, particularly if the research budget of the Department of Defense were held level, which, looking back in the previous year, seemed to be the intent of the Congress. In fact, the NSF participated and provided much of the staff work for the study I refer to, which was just the beginning at this sort of thing. I suppose it might have originated at an earlier time from NSF all by itself, but when one sees the necessity, one goes ahead, and that was, I think, the basic history. NSF participated very intimately in getting together the data for the assessment I mentioned, in the fall. But that is just really the first step. It would have been very hard, from within the NSF, however, to have arrived at the other major conclusion of the budgetary discussion last fall: that NSF's share in the Federal support of research ought to be increased somewhat. This year's budget would increase the NFS role from 14 percent to something like 19 percent. Now, one may call that carving it up, but it is actually a more fundamental approach. I don't believe NSF can exercise the role that was intended for it unless it is responsible for somewhat more than that 14 percent. I don't know what the optimum fraction is, but I think that NSF has, in fact, to be the source of a fairly considerable fraction of the basic research support if it is to really exercise its basic functions.

Mr. DADDARIO. I am sorry that I stopped you in the middle of the paragraph: I have been trying to wait until you finish. You were in the second sentence of that paragraph.

Dr. HORNIG. I had mentioned as a result of this study, which was participated in very intimately by the Foundation, that we had looked forward to the anticipated total needs of the Federal Government. The Foundation took the study into account and responded to this need in its fiscal year 1966 budget request. I hope that the Congress will recognize that the National Science Foundation must perform a "balance wheel" function in maintaining a steady and healthy overall growth in American science and science education, taking into consideration other sources of support.

To accomplish this task it will be necessary to increase the NSF's fraction of total Federal support in the universities substantially above the fraction in past years. If, as now seems likely, this increase in the National Science Foundation's fiscal year 1966 budget is not granted by the Congress and the academic research budgets of other agencies are cut, the 10 percent more graduate students in science, who will be there next year will not be as well supported as their predecessors.

A second type of relationship between the Science Foundation and the Office of Science and Technology characterizes the relationship between OST and all Federal R. & D. agencies:

1. The Office of Science and Technology and the President's Science Advisory Committee review and examine the programs of the National Science Foundation in the same way as they look at the programs of other agencies. Because of the smallness of the OST staff resources, this examination is highly selective and concentrates on items of major importance. The Office of Science and Technology does not attempt to systematically cover the detailed programs of the agencies. It is concerned mainly with the directions in which the programs are tending, the opportunities that may be neglected, and the major budgetary issues. It endeavors to assist and encourage the agencies themselves to strengthen their capabilities, quality, and resources so as to lessen the need for detailed involvement of the Executive Office agencies.

2. The Science Foundation participates as a full member of the Federal Council for Science and Technology in coming into agreement with other agencies on common policies for the administration of research and development, and in developing a consensus on the level and distribution of effort desirable for broad areas of research that cut across the programs of several agencies such as those in oceanography, high-energy physics, and atmospheric sciences.

The detailed work of the Federal Council is accomplished by means of a number of panels in substantive areas. Most of the panels are chaired by agency personnel. It is necessary to rely on the Science Foundation and other agencies to provide staff assistance to the panels and to undertake analyses in depth as will assist overall review and evaluation of the technical program area.

I have sketched in general terms various ways in which the Office of Science and Technology and its associated mechanisms interact with the National Science Foundation. Although this relationship has been productive, major problems lie ahead which will call for stepped-up efforts to develop new and improved approaches to the planning of the Government programs for the support of academic research and

for relating this research to the large science programs aimed at particular national objectives. This, in turn, calls for even closer cooperative efforts between the OST and the NSF. This summer the President's Science Advisory Committee is undertaking a 6-week study which we regard as a first step in the direction of developing guidelines for Federal support of academic research. The study will rely heavily on the staff resources on the Science Foundation and will inquire into such matters as the criteria for distribution of funds for research at the universities so as to reinforce the scientific excellence that exists in selected institutions, to increase the number of first-rate institutions, and to broaden the base of scientific research and education. There will be consideration of ways to broaden the geographic distribution of support to universities. The balance between project support and increased institutional responsibility for larger program elements will be examined. The role of postdoctoral students will be studied to determine whether policy guidelines for their support can be developed.

Mr. DADDARIO. What will result from this PSAC study, particularly with respect to its effect on the budget You have obviously put it together for some reason, and I wonder what your objectives are in that regard.

Dr. HORNIG. I think our objectives in the first instance are to understand the situation, to try to decide what our goals ought to be, and then, of course, if we can find a rationale for our continuing development, to translate that into budget and action items. But in the first instance, this study is to begin to try to understand and delineate what we are up to. I think this is characteristic of the Science Advisory Committee, in that it is not involved as deeply in the immediate operational aspect of the Government as in its attempt to provide a good intellectual framework for governmental policies. Its members are, of course, primarily from outside of the Government.

Mr. DADDARIO. On the previous page you talked about the work in oceanography, high-energy physics and the atmospheric sciences. These cut across the broad areas of research. How do you see NSF's function in this regard in the future? Do you envision an increasing role of this type?

Dr. HORNIG. Let me cite an analogy to a typical research laboratory. A problem that all advanced industries face is that there is applied and developmental work which is aimed at either the products they are producing or at finding new products. These are the mission-oriented parts. Most of the advanced industries also have found it important, however, to maintain some sort of a central research laboratory which is divorced from the short-term needs in order to lay a general base for the future.

The situation is somewhat analogous here, in that in areas like atmospheric science there is a very practical problem, and that is predicting the weather. We are all concerned with it, and this is the job of the Weather Bureau. Some research has to be done which is directly tied to the operations of the Weather Bureau and over a reasonably short term improving its operations. Work has to be done to assimilate the latest findings of basic research in the atmospheric sciences relating to, say, the total circulation of the earth's atmospheric, mechanisms of precipitation, and so forth, getting this into the

weather forecasting process. But above and beyond that, if all of the researching we do is tied to, in this case, weather forecasting, one would have no basis for longrun improvement, for example, for someday tackling and being successful with the problem of modifying the weather to suit our needs. So there is a separate problem of promoting the understanding of what makes the weather in the first place, and that is the central role of the National Science Foundation, whereas the prediction of the weather is the role of the Weather Bureau. There is never going to be a completely clean line between those two functions, but they are different.

Mr. DADDARIO. Then you do see an increasing role for NSF in this kind of operation?

Dr. HORNIG. I think the central role of the NSF was well stated by the Congress in the first place; I have given just this one example, but it is to insure the health of the underlying basic science and science education on which our whole structure of applied science and practical application depends in the long term.

Mr. DADDARIO. How far can NSF get into the practical application under the organic act?

Dr. HORNIG. Under the organic act, it is not completely crystal clear. It can't get very far, because the organic act directs it to provide for basic research. It also provides for engineering education, and there is, of course, a slight contradiction in terms, perhaps, in words like basic research in engineering, since engineering is concerned with the application of knowledge. So to that extent I suppose the organic act is a little bit ambiguous, but for the most part the organic act certainly restricts the NSF to basic research. I think there is a genuine problem here, when one worries about the transfer of basic research to applications in areas where we have no agency which is waiting as an avid consumer. I haven't thought this through completely, but it seems to me that one must examine whether the NSF perhaps shouldn't place a little more attention here, perhaps the legislation should be modified, but I want to think this through further, to enable it to devote a bit more attention to the information transfer problem, the transfer to applications.

Mr. YEAGER. Might it not be a good idea for the NSF to become a little more involved in applied science where issues of broad public interest are concerned, such as pollution or something of this nature? At least it might be made permissive.

Dr. HORNIG. It might. The reason I say I want to think about it, going back to my analogy of industrial establishments, the reason that most industries insulate their central research laboratory from their technical laboratories and their technical service laboratories is the danger that the demands of the day-to-day needs will overwhelm the needs for basic research, which are never urgent in the next month. We must consider if, by assigning too many practical tasks to NSF, one might not overwhelm the basic function that it serves so well.

Mr. DADDARIO. The other danger is that of being completely isolated so it will not bring about the transfer of the practical applications. The question is should the National Science Foundation be restricted to basic research, so isolated, so as to not have the capability to become involved in the fields of practical application? I know you have already touched on such areas as the atmospheric sciences. Is it beginning to move in that direction anyway?

Dr. HORNIG. I think this is a matter which deserves intensive study, and the Science Foundation, of course, is thinking about it and will make its recommendations. It is certainly something that we have been thinking about. Quite aside from the Science Foundation and all of science, I have been worried about the balance between basic research and applied research and the problem of bringing them together so there is an efficient flow of innovation into not only applied research but into industry and industrial practice.

Mr. DADDARIO. You raise some intriguing points in this regard, Dr. Hornig, and I am pleased that you have raised them.

Dr. HORNIG. Beyond the matter of Federal support of scientific research and education in academic institutions, there are major questions which we will need to probe regarding the evolving role of the Science Foundation in supporting science. There is the question of increasing NSF support of scientific activities that are directed at particular national goals without neglecting scientific opportunities as identified by talented scientists. There is also the question whether proportionately more attention should be given to programs and measures to promote the application of scientific knowledge when it does not fall within the purview of one or the other of the mission-oriented agencies. This would include measures for improving the national systems for the dissemination of scientific and technical information, and increased attention to education and academic research in engineering.

In summary, Mr. Chairman, the structure for national science policy formulation and management has evolved in recognition of the importance of maintaining the diverse pattern of support of research and development by the many agencies of the Federal Government since research and development cannot be uncoupled from the practical purposes which they serve. The National Science Foundation can play a most valuable role by helping to develop national science policies, by contributing its experience in carrying out its broad responsibilities for support of research and education in the sciences, and by making its professional and statistical resources available to the Office of Science and Technology.

I will be glad to answer any more questions.

Mr. DADDARIO. Dr. Hornig, have you thought out the ways in which increased attention to education and academic research in engineering ought to develop?

Dr. HORNIG. I will give you some views, but it is a question which is still very much under discussion within, for instance, the Science Advisory Committee. Engineering education has undergone a revolution since the last war, and largely in the direction of engineering sciences. One of the things that emerged during the war was the importance to engineers of having a sound theoretical and scientific foundation. There has been in our engineering education a reaction against the old cut-and-try kind of engineering. There is no question whatsoever in this respect that the quality of engineering education has improved very markedly in the last 20 years. Nevertheless, there are people now who inquire whether we haven't overshot the mark, whether engineering training, particularly at the advanced level, hasn't gotten a little bit removed in some cases from the basic objective of application, whether graduate research for the Ph. D. engineering

degree shouldn't take some other form than essentially the pure research of the physicist or the chemist or the mathematician. I don't have an explicit recommendation here. I think there genuinely is a problem in engineering education in both retaining this sound theoretical foundation which allows the engineer who is trained today to have a base for dealing with the problems of 10 or 20 years away, on the one hand, but also having an outlook which focuses on doing things rather than studying things. I think, in a nutshell, what some people are worring about is we may be moving too far in training a generation of engineers who study things rather than carry them out. However, I am sure that Mr. Vivian understands this problem very well.

Mr. VIVIAN. They seem to manage to carry out a large fraction of the national budget so far.

Dr. HORNIG. This I should say: In the conduct of our space program, our defense programs, and in the growth of our industries, our engineers have acquitted themselves very well, despite these observations.

Mr. DADDARIO. Do you have any questions, Mr. Roush?

Mr. ROUSH. I am not sure whether or not this has been answered, perhaps indirectly, but I have on my desk a report, a favorable report, from the Government Operations Committee concerning the proposal for a Commission on Science and Technology. How do you feel about the establishment of such a commission, Dr. Hornig?

Dr. HORNIG. My view a year ago had been that we ought to have more time to see how the relatively new mechanisms we had established were going. I think enough time has elapsed now so that I, myself, think this might be a good idea. I certainly wouldn't object to it.

Mr. ROUSH. I have no other question for the present.

Dr. HORNIG. May I amplify my previous remark simply to say that my answer was a general one, and I am not prepared offhand to comment on the specific terms of reference of the proposed commission.

Mr. DADDARIO. That is flexible enough.

Mr. MOSHER. Dr. Hornig, within the Government where does the prime responsibility lie today for the dissemination of scientific information, that is, a central point for making available information efficiently and readily? Does any one agency have this responsibility, or should any one agency have this responsibility?

Dr. HORNIG. There is no one point that is responsible for the dissemination of all information. I think it is doubtful whether one wants one point.

To look back at the classic problem of information dissemination in this country—this isn't a new one—one can look at the library system. We have a Library of Congress which contains samples of almost everything that is printed. On the other hand, no one would urge really that everyone who wants a book ought to get it from the Library of Congress. So, the important question is whether there exists a good mechanism by which anyone can get to the desired information.

At the present time, though, there exists no central planning responsibility for such a mechanism or system, which may be more important. To cite a few things, the Office of Technical Services in the Department of Commerce does have the responsibility for being a single point of access to all of the Government report literature, so

that information that is generated as a result of Federal R. & D., and which is not classified, can all be obtained from the outside through the Office of Technical Services. But beyond that the National Library of Medicine undertakes the principal role in the dissemination of medical information. The Atomic Energy Commission, the Department of Defense, and the Department of Agriculture all maintain information services which work within their specified areas. At the present time the Committee on Science and Technical Information of the Federal Council and Mr. Knox of my office, have taken a central role in trying to tie these together in a planning sense, but I think we must look forward to an agency outside of my office acting in the long term as a central agency for knitting together these separate information systems.

I think again this is something I would hate to provide a final answer to. One might set up a new agency but I am very worried about setting up science information specialists separate from the people who deal with science in substance. So, therefore, I have thought quite a lot about the fact that the Science Foundation is really the only existing agency with a broad enough interest to undertake this role.

Mr. MOSHER. This was the question I was going to ask. Do you see NSF as taking a larger role in it?

Dr. HORNIG. I don't want to prejudice the studies which are now underway and which involve quite a lot of people trying to understand in detail what these general concepts they have been discussing translate into terms of potential action, but I think I would say that the simple answer to your question is yes, I think the NSF ought to play a considerably expanded role. The only question is how big and of what nature.

Mr. MOSHER. As a layman and having very little awareness of these matters, I am curious to know what is done with the results of the academic research that the NSF funds. Are the results practically all published in the proper journals and that sort of thing?

Dr. HORNIG. The results are practically all published in journals.

Mr. MOSHER. Then, does NSF take any responsibility for making available the results of the research that it supports?

Dr. HORNIG. It help subsidize journals, for instance, since they don't take advertising for the most part and many of them have trouble keeping alive.

I would like to make one general philosophical statement about science information. Science does not consist of a collection of facts. One of the most important functions is the assimilation of facts in generalizations and boiling them down to ways in which they are useful. Sometimes in thinking of science information, people are inclined to talk as if the problem was just to be sure that all the facts were disseminated. In fact, the Weinberg panel, which studied this matter for the President's Science Advisory Committee made a strong point of the fact that we must in some ways consolidate the information and weed out some of it, even at the very beginning; that it is not a desirable goal for the country simply to get everything written down somewhere. This contributes not only in science but everywhere to these mounds of paper. Someone eventually has to use them. If one fills up, whether it be computing machines or journals, with too much

trivia, one may in effect hide information just as well as if it weren't printed in the first place. So, this takes a lot of careful thought and design.

Mr. DADDARIO. Dr. Weinberg will be a witness, Mr. Mosher, and we can go into this in greater detail at that time.

Mr. Brown.

Mr. BROWN. Dr. Hornig, this may get a little bit off the point, but I have been very much concerned about the broad role of the Federal Government in supporting only certain types of research which is basically mission oriented.

This is true not only of the mission-oriented departments, such as Defense, AEC, and so forth, but it is even true of the National Science Foundation to a considerable extent. There is a trend toward filling in the gaps between what the mission-oriented departments have failed to cover. In a sense, it is still related to a mission. However, historically, before World War II, for example, the net total of basic research in this country was more determined by the decision of individual scientists as to what was important to their science. What contributed to the total of human learning and so forth. I see a particular problem arising right now in that we are failing to move in certain areas where it may be extremely important to the future of the country. For example, there is a rather serious lack of understanding of the way in which people in the world think, or the way they are organized, or the way they are developing. We seem to have spent a great deal of time trying to understand the people of South Vietnam, for example, but there is no research at all on this subject. I am concerned about our present methods of supporting large basic research and the effect it has on this kind of problem. Is there anything that can be done to correct it? I use South Vietnam as only a very small example of this failure to get important knowledge of what is going on in the world that would be important to the United States.

To a considerable extent this may be classified as social research or anthropological science or various other areas of science. I notice in going through your testimony that science seems to be almost synonymous with physics, chemistry, mathematics, and engineering.

Dr. HORNIG. And biology and oceanography.

Mr. BROWN. But the things I am talking about have been substantially neglected—economics, sociology, anthropology, various things of this sort.

Dr. HORNIG. You have asked several separate questions and I will try to take them up one at a time. I don't believe it is a fact that our basic research is being steered by the mission-orientation of the agencies at the present time, at least in the universities. The mechanism by which the NSF, for example, funds basic research is to solicit proposals from the university investigators, which are judged by panels of other scientists.

Mr. BROWN. May I interject at this point, and I know it is a hardship on you, but isn't it true that the proposals that are made by the researchers are at least slanted by what they think is going to be funded in terms of the history of previous funding, and the mission orientation of the panels that are making the decisions?

Dr. HORNIG. It is very hard to talk about what goes on in the minds of people you don't know. I can only state that in the universities

with which I have been associated since the war I saw no evidence whatever that proposals were slanted by what the investigators thought someone was going to say about them.

What does happen is that once a man has written his proposal he decides whether to send it to the NSF or to the DOD, and at this point he certainly gives very careful thought as to who is likely to be interested in it. So there is perhaps a more subtle effect of that sort. But I saw no evidence in any of the universities with which I have been acquainted of people picking their problems because they thought that somebody in Washington would like it that way. This has been true I think, in large part, of the Department of Defense support of basic research as opposed to the much bigger volume of their applied research and developmental activities, which are highly directed.

I think that you raise a very central question in regard to the need to give attention to two different approaches in the selection of topics. One is that at any given time there are topics which are important because the Nation needs to know the answer. The other approach is that which tends to come out of the basic research community as oriented toward the importance of topics in terms of their relation to the science at any given time and topics which contribute most to the fundamental understanding. The NSF certainly has been oriented almost solely, as has a good part of the NIH activities, to this latter role of developing the broad scientific understanding. And the proportion of our research which is basic has actually been rising, in time, very gradually since the last war.

The second question that you raise, of course, is quite separate. You ask about the social sciences, and, of course, I think they deserve your support. But when you ask about Vietnam, for example, you are asking about a practical need of the country. I don't know whether, left to their own devices, the anthropologists would pick Vietnam as a particularly interesting place to study or not. But exactly the point I am making is: There is the decision that an anthropologist would make who is interested in anthropology, and there is the decision that we would make, because we are interested in Vietnam for other reasons.

There is, of course, very extensive support at the moment for research in foreign areas. One of the things that has happened in universities has been the development of Far Eastern programs, of Mideastern programs, of Asiatic study programs, of Russian programs. I can't think of a single major university that hasn't, within the last 10 or 20 years for the most part—some go back much further—developed some of these regional study activities.

There is a division, nevertheless, between natural science and social science, and I am not myself competent to discuss offhand the adequacies of our support for the social science to which you were referring. I am not aware of acute problems, but I think it is certainly something we should look at.

I am not sure whether the National Science Foundation, however, should take on additional responsibilities in this field, particularly in areas involving policy. These problems are sufficiently different from the area of natural sciences around which the National Science Foundation was built that, to me, it would be a serious question whether other public and private organizations shouldn't undertake that primary responsibility.

Mr. BROWN. But why? Isn't the mandate of the National Science Foundation broad enough to encompass the social as well as the natural sciences? Why should we duplicate, or have another foundation parallel the work of the National Science Foundation?

Dr. HORNIG. The Foundation does at the present time support the social sciences to the extent of about $10 million per year, but they are somewhat more concentrated at the experimental end of the spectrum. It is mostly experimental psychology, for example, rather than social psychology, that the Science Foundation supports. I don't know that I can give a simple answer to where the cutoff should come. It is a question of what one interprets basic research in the sciences to be. Our interpretation so far has been to retain the word "science" as applying largely to the natural sciences or the sciences that are related to experiment, though this has moved off some into economics, some into experimental psychology, but, broadly speaking, we have not, as a matter of fact, regarded the social sciences as the central part of what the Science Foundation was intended to do, particularly in examination of policy areas. This intent, of course, could be changed by Congress. My reason for this is simply that it has a very big job to do in the areas in which it is working so well, that the people that would be required to man an effort for the support of a major part of the country's economics, population studies, anthropology, are just a completely different set of people. I think it would be unwise to attenuate the efforts of the Science Foundation at this time unless major new funds were to be provided, and major new organizations, although it might be part of the Science Foundation, were to be set up. I hope you appreciate I am just talking off the top of my head here, and I have not tried to think through this question.

Mr. BROWN. We are dealing with a very basic policy problem here. Frankly I feel that your responsibility as Science Adviser to the President should contemplate some evaluation of policy in this field, and I think your last remark has just indicated what seems to me to be an attitude that has grown up. I will stand subject to correction if it hasn't grown up during this period of governmental support for the natural sciences—an attitude that natural sciences are the sciences, that other fields of science really aren't entitled to full status or stature in the gamut of scientific activities in the world today. There are many other areas which seem to me to need support. The whole problem of pathology in our society today, for example, the problems of criminology and how to deal with them, as far as I know are not receiving the type of attention that is being devoted to what you call the natural sciences. From the standpoint of the health of our society, these are as important today as putting more dollars into high-energy physics. Now this is a policy question admittedly. I am concerned with how these policy questions are going to be resolved at your level, and as far as the functions of the National Science Foundation are concerned.

Dr. HORNIG. If I have given the impression that I think the natural sciences are in any way superior or exclusive, then I did not state my views correctly. But I would say the President has a Council of Economic Advisers, for example.

There are many agencies of the Government concerned with the social sciences, applied and theoretical, so my statement was only

that at the present time my own organization and the organizations we have assembled have their major competence in the national sciences, and this doesn't in any way play down the importance of the social sciences or any of the other areas of the Government. We have in fact been in consultation with the president of the Social Science Research Council trying to explore the question of what needs doing and what possibilities are. I am very much interested in these areas, but I think what I would say for ourselves is we haven't come into any clear focus as to what the proper course of action in the nonnatural science areas is. That in no way is a statement that I consider them less important. I think in fact the situation is they are just beginning to come into their own as sciences, and it is very likely to be true that in the future their role will be much more important relatively than it is now.

Mr. BROWN. You wouldn't recommend that the title of your position be changed to "'Natural' Science Adviser" to the President and the foundation be the Natural Science Foundation, would you?

Dr. HORNIG. I would have no objection if this were really the will of Congress. Seriously though, I would like to make one other point, that one of the key problems in the social sciences, of course, is the number of people available.

Mr. BROWN. In your earlier remarks you indicated that you felt that science was being funded on the basis of the proposals coming in and that there was no bias toward the natural sciences, that the best proposals were being funded in all the sciences.

Now, I would like to know if there is some way of verifying whether or not there has been this impact on those areas which have been funded. Maybe we could perhaps tabulate the number of researchers during the period before the major impact of Government funding took place and after. Has there been a change as a result of the Federal Government's funding during the last 15 years?

Dr. HORNIG. There has not been a major change in the distribution between scientists and nonscientists. One of the very interesting things which emerged from the National Academy's publication of Ph. D.'s between 1920 and the present time is that the proportion of Ph. D's between the science and nonscientific areas has not particularly changed over this whole interval.

Mr. BROWN. By nonscientific areas do you mean the social scientist?

Dr. HORNIG. The breakdown is more than that in the Academy statistics, but between the natural sciences and the rest of the Ph. D.'s there has not been any drastic change in the proportions at all.

Mr. BROWN. I think this is a very significant bit of data bearing on the point we are discussing here.

Dr. HORNIG. I think I would like before answering a question like yours in any great detail to look at the social sciences in the sense that we are now examining some of the natural sciences, which is not in terms of proportions of money spent but whether good people are or are not adequately supported in the work they were doing. For example, again I could only say in the universities with which I have been associated my impression is the standards of support were reasonably good in the social sciences. But this again is a very small personal sample and not a basis for making a general statement.

Mr. BROWN. The things that really are of concern, and I think are of concern to the country, are the problems that we are trying to solve. I think in today's world the social scientists are still going to have to use many of the mathematical and the computer techniques and technologies and many other things, that the physical sciences are using, but they are going to have to apply them to a different set of problems. It is the direction of the problems that we are getting at which is of basic concern to me. I want to know the degree to which this is affected by our scientific support of policies. I hope this will come out more clearly over the course of these hearings.

Dr. HORNIG. I think there should be mentioned, of course, some of the beneficial effects to other fields from Federal support of the growth in natural sciences, which was already before the war beginning to place an inordinate strain on the other resources of the universities. This growth in Federal support of the natural sciences has demonstrably had the effect of freeing up money from other sources, such as foundations and the internal resources of the universities, and it is fairly easy to see that these sources of support have in large measure shifted to the other goals while this process was going on. So it is a very complicated matter. One really does have to look at the funding of research in all areas during the same period that we are talking about here.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I have five or six questions which I will try to get through very quickly. As to the budget request, most of the major appropriation bills already have come before the House. Are those bills which have already passed the House below the desired appropriations for research, not just for NSF but for all the agencies?

Dr. HORNIG. I do not know if I can recollect from memory all of the actions. In the case of the HEW appropriation, everything that was asked for has been appropriated. In the case of the Department of Defense, the budget called for something like a 7-percent growth, and I believe that the House action would lower that to about 4- or 5-percent growth. But reprograming, based on the general recommendations of the House, could cause a decrease. In the case of the National Science Foundation, the budget called for approximately a 50-percent growth in the basic research component.

Mr. VIVIAN. You said 50 percent?

Dr. HORNIG. Fifty. And the House action cut that to about a 25-percent increase in the basic research component. Of course, reprograming is possible, and the Senate has not acted. I think, except for this NSF action, the cuts have been small, but they have all been in the direction of cutting back on the budget. Of course, although these budget cuts in the other agencies appear to have a small effect on the overall totals, they are large in terms of the growth rate and we would not like to see the support of basic research in universities stagnate in these agencies.

Mr. VIVIAN. That is true of many other budget items as well, the trend is generally toward cutting back?

Dr. HORNIG. Yes. Basic research in all the mission agencies is buried in very many budget items, and it doesn't always appear as

explicit items. There is also the question of what reprograming will occur after the budget action.

Mr. VIVIAN. For example, the NASA budget has not been cut substantially. You suggest that the NSF budget is the only one that has been materially cut, and this primarily in the basic-research support in which 50-percent increase was requested?

Dr. HORNIG. That is substantially correct.

Mr. VIVIAN. Let me switch to a second question. Relative to the distribution of scientific information, the National Science Foundation has a certain goal and is active in it. The Department of Commerce is also interested in a bill, which I am sure you are aware of, regarding State-Federal technology centers. To what extent is this in conflict with the interests of the National Science Foundation, or to what extent has this been so examined by your Office as between the two agencies?

Dr. HORNIG. I do not think there is any conflict whatever with the National Science Foundation's activities. That bill is designed to get technical information into the hands of local industry. It is a dissemination activity primarily. I think the Foundation's primary role is in the design and evolution of information systems in a much more general sense.

Mr. VIVIAN. In other words, you do not construe the National Science Foundation to be in the role of disseminating information?

Dr. HORNIG. I don't see why it should; no.

Mr. VIVIAN. There is no conflict at the level of your Office in these bills?

Dr. HORNIG. There is no conflict.

Mr. VIVIAN. On page 7 of your testimony, approximately the 10th line down, is the statement:

> It also permits the Foundation to take the lead, when requested by the Office of Science and Technology, in organizing and carrying out interagency studies and evaluations.

Can you give me some examples of those interagency studies and evaluations? Three or four will be sufficient.

Dr. HORNIG. A recent one, which I mentioned elsewhere in my testimony, was after the submission by the Academy of the ground-based astronomy report; the Science Foundation undertook, working together with the other agencies, to assess what the plans of NASA, DOD, and everyone else were in this area, with a view to seeing what the national ability to implement these recommendations might be.

Now, as a smaller example, in the scientific information area, the Science Foundation, at our request, took the lead in bringing the NIH, DOD, and themselves together in supporting the Chemical Abstracts proposal for developing a mechanized information system for chemical information.

The NSF has taken the lead in the upper mantel project for coordination of the geophysical research on the earth's crust.

It has taken the lead, and is still continuing a study, on university computers. This is becoming, I might say, a very major problem because the demand for computers is so great, and they are so obviously an essential item to science and technology and its future, that there are real questions as to how they should be supplied and how they

should be funded when they are in universities. This is another area in which the NSF has taken the lead.

Still another I can think of is with respect to the science information exchange, which is funded by the NSF but which serves all the agencies. NSF is undertaking a study now of user needs, because one of the real problems in all science information activities is to couple, if you like, the technology of the information specialist to the needs of the people who use it.

Mr. VIVIAN. Supposing we take atmospheric research, for example, in which all the other groups are very active. Has NSF here had any significant role in coordination?

Dr. HORNIG. Here the main coordination has taken place in the Interagency Committee on the Atmospheric Sciences on which the NSF is a very important member.

Mr. VIVIAN. Why should that be handled differently than these other matters?

Dr. HORNIG. For one thing, because NSF is a minor partner in the total funding, on the one hand, and, secondly, it is coupled tightly to a very big operational program: the weather services of the country. I should mention that is not unique. Oceanography is another similar case. This is coordinated among the agencies by the Interagency Committee on Oceanography on which NSF is a very important member. NSF, in fact, plays the key role in the support of oceanography as science, but it is supported for many other purposes. It does not play the leading role in determining the role of oceanography in what I would call, if not nonscientific, at least applied scientific aspects. I think that tends to be the pattern—that, where it concerns principally basic science or science education, NSF plays the lead role.

Mr. VIVIAN. I want to come back to what I think is underlying so much of this. As I understand the structure, you are the chairman of the President's Science Advisory Committee; is that a correct statement?

Dr. HORNIG. I am the Chairman of that Committee, but by election by the Committee. Just for information, this is a debate the Committee has every year.

Mr. VIVIAN. I can understand that. You are appointed directly by the President, and you report to him, whereas the Director of the National Science Foundation reports directly to a board. That Board is appointed by the President, and the appointment of the Director is also a Presidential appointment; but, after being appointed, the Director reports to the Board; is that correct?

Dr. HORNIG. That is correct.

Mr. VIVIAN. In other words, the reporting chain differs in that Dr. Haworth reports to the Board which is, shall we say, the top ceiling, whereas in your own case you report to the President?

Dr. HORNIG. That isn't quite correct. Let's put it this way. Dr. Haworth is responsible to the Board, but he certainly reports directly to the President in administrative matters. The Board is responsible for setting broad policies for the Foundation, and in that sense he is responsible to them.

Mr. VIVIAN. I am not here for the purpose of embarrassing either of you gentlemen. So far as I can determine, the so-called PSAC committee does not interweave itself between you and the President

whereas the NSF Board could be construed as so doing in the case of Dr. Haworth. Then, another vein of this, that particular Board is composed, I believe, of primarily academic personnel—that is, persons derived from academic background. Is that a correct statement?

Dr. HORNIG. The majority of the Board is; yes.

Mr. VIVIAN. It is often labeled as the "big university committee," as I am sure you are well aware. If it had a coordinated role through all of science, through the many missions and agencies, and if it were comprised of people primarily from the big universities—which it is—then, it would have a rather peculiar role relating to science and national defense. Doesn't the change which established your office reflect the fact that the Board didn't necessarily reflect the interests of persons engaged in Defense Department research, or persons engaged in NASA research, or persons engaged in NIH research, but it reflected the interests of the major universities? In other words, didn't the existence of the Board obviate the possibility that NSF could carry out its initial functions?

Dr. HORNIG. I do not think I would quite agree with that analysis, in that the central function of NSF was defined in the first place as the health of basic research and science education in this country. This was its main mission in life. The Board I think has been excellently suited for carrying that out.

It was also assigned the responsibility for setting broad science policy for the whole Government and evaluating the programs of other agencies. I believe this was a secondary intent of the Congress and not the central one. I think there are a whole complex of factors that make NSF not suited to evaluating, for instance, the military development programs of the Department of Defense, of which the composition of the Board is only one of the minor ones.

Mr. VIVIAN. It was my impression that it was the intention of Congress that the setting of policy was to be a very important step, and that this has been found to be an untenable position. And, being untenable, a new approach was followed.

There have been many questions that have related to the interrelationship between these various offices. I must admit I am more satisfied with the present arrangement than the previous one, but the interrelationship is far from clear. As I have read the testimony, I am left with the conclusion that if I were in the position of the Director, as Dr. Haworth is, I would sometimes not quite know what I shouldn't do. In fact, I would frequently not know what I shouldn't do, except I would have tested out these endeavors in the hard course of ordinary life and discovered that some got me in trouble, much more trouble than others, and I would leave those alone. I would say that the policy statements and words are downright meaningless.

Let me go on.

Mr. DADDARIO. You don't want an answer to that last question?

Mr. VIVIAN. I don't think anyone here would like to answer it.

I would like to go on to another matter, the international role of the United States in science. As far as I can tell, the National Science Foundation is only marginally engaged in sponsoring science on an international basis; that is, sponsoring scientific work elsewhere, with the exception of some of the special programs such as IGY. The Office of Aerospace Research of the Air Force has a large-scale role

in international science. I base this partly on reading the reports of OAR and being at its conferences. The Department of State seems to have a much smaller role. Is your office personally concerned with the international role of the United States in science? Is this part of its purview or not?

Dr. HORNIG. Yes.

Mr. VIVIAN. Is there any policy statement which has been established as to the relative role of these several agencies in sciences internationally?

Dr. HORNIG. Well, there is a general statement that all of the international activities will be overseen in a general way by the Department of State.

There are many kinds of international activities, and I am not sure what kind of a general statement one would make. There are the kinds of things we do internationally in science in pursuit of nonscientific foreign policy objectives of the United States. There are ones that are aimed at securing general international cooperation. There are the ones which are concerned with utilizing foreign scientific capabilities to supplement our own in some areas. After the war for a while this sort of foreign science assumed some of the facets of Marshall plan aid. So, there are many kinds of objectives.

Mr. VIVIAN. Let me go to a particular one. There are many others that I am very interested in, including those referred to a moment earlier by Mr. Brown, but one particular one is personally interesting to me. I refer to having a major international role played in the future Voyager system to Mars, since I believe this is one of the better ways of generating a scientific program, where there can be no military arguments brought out. In my discussions with NASA people during the budget hearings, I asked questions about this, and the answer was that this was not their purview. I have the feeling if I were to ask the Department of State, they would say that this is not within their purview. I think I could give a long list of agencies of whom I could ask that question, all of which would say it is not their responsibility. Now, is it your responsibility?

Dr. HORNIG. I am interested and concerned. Yes, I suppose it is my responsibility.

Mr. VIVIAN. And no one else's, at least not directly?

Dr. HORNIG. Well, NASA has very extensive international programs. I would not like here to take issue with them without having explored the matter. It is not quite clear to me why this matter is not also of interest to their international division.

Mr. VIVIAN. In other words, the international division of NASA would be authorized to establish a policy relating to this particular item?

Dr. HORNIG. I am afraid I am not prepared to comment offhand on the internal structure of NASA, but certainly international cooperation has been one of their goals in the space program, and they have established very extensive programs in international cooperation with respect to other programs.

Mr. VIVIAN. This did not require the initial authority of your own office?

Dr. HORNIG. Not on individual programs, certainly not.

Mr. VIVIAN. Fine. Thank you. I have no other questions Mr. Chairman.

Mr. DADDARIO. Dr. Hornig, did you want to say something further on that?

Dr. HORNIG. With respect to the question I didn't answer, I would like to get emphatically on the record that OST, in general, does not interpose itself between the heads of agencies and the President. I mean we are basically a staff office to the President; so, the administrative lines reach from the heads of agencies directly to the President. That is all.

Mr. YEAGER. One question, Dr. Hornig: In connection with the 15-percent increase in the Federal sponsorship for basic research which has been suggested to us by the academy and I believe by Dr. Haworth, and I think you have mentioned it. If it becomes a national policy to increase this by 15 percent a year, and if the source of funding from private, statewide and other sources doesn't keep pace with this—and my understanding is that this is at the rate of something like 5 or 6 percent a year—if this goes over a long enough period of time, don't you arrive at a situation where the Federal funding in the universities constantly increases in proportion so that you might have what some people have referred to as Federal universities? Do you see this as a danger, and should this be reviewed after a period of time to see whether this percentage arrangement really ought to be continued?

Dr. HORNIG. You have asked several questions. In the first place, we have not taken the position that it should grow at 15 percent a year for many years into the future. The position in our case was only taken for this year and based on facts available for this year. To look ahead further is one of the central purposes of the study I mentioned that we are currently carrying out, because the arguments need considerable analysis and refining. So I have no position at the moment on 15 percent per year into the future.

As to the effect of increased Federal funding on the universities, there are obvious dangers, because with funding there is always the possibility of control. But up until now I would say that effect has been a very healthy one. There have been problems, but the problems have been worked out. I think the universities have retained their independence in the scientific area. I think the general vitality of science in America exceeds that of any other place I have seen. During the very period under discussion, this has been a period of scientific flowering in America. Nonetheless, the problems you raise are real ones and it is therefore going to require continued good sense and attention by the executive, the Congress and by the universities themselves, in fact by the whole community.

Mr. YEAGER. So you would go slow in establishing a national policy on this basis or attempting to establish for an indefinite period of time any given percentage increase?

Dr. HORNIG. I think the statement about a percentage increase is just too narrow a statement of a plan. One doesn't increase everything certainly at that rate. I am certain there is no policy ever going to be generated that says increase everything by 15 percent. The minute you get beyond that, you talk about the evolving structure and needs, which is a much broader discussion.

Mr. VIVIAN. Mr. Chairman, I have a very broad remark to make on the subject that has just been brought out. I have had experience with persons complaining because of greatly increased Federal support for a wide variety of activities in modern life. I am forced to remind them that State legislatures have never been proscribed from providing more support for universities, in my State they do; they have never been proscribed from providing support for water pollution control measures, which they have never done, and I can give you a whole list.

Mr. DADDARIO. Dr. Hornig, we have some questions which I hope we will be able to send to you for the record.[1]

Dr. HORNIG. I would be happy to answer them best I can.

Mr. DADDARIO. I would like to add one item with reference to this last point which was raised, and I am inclined to agree very strongly with Mr. Vivian, I see in your statement where you say "taking into consideration other sources of support," that you are aware of this, too. View the entire situation, not only what is being done in the Federal area, but also what is being done by the States, what is being done privately. In the final analysis it is how they work together that is important. I note in your statement also that you refer to NSF as a "balance wheel."

It is my feeling that you meant it in this way.

Dr. HORNIG. I think that your statement is quite correct. When I say NSF should act as a balance wheel, I, of course, no not mean in any sense that it should be a responder to what everyone else does.

I hope, intellectually, that it will provide leadership. In the sense you mentioned that must mean balance wheel.

Mr. DADDARIO. Yes.

Thank you, Dr. Hornig.

This committee will adjourn until 10 o'clock tomorrow morning at this same place.

(Whereupon, at 12:20 o'clock, the committee was adjourned to reconvene at 10 o'clock, Wednesday, June 30, 1965.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

WEDNESDAY, JUNE 30, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. The meeting will come to order.

Our first witness this morning is Dr. Frederick Seitz, President of the National Academy of Sciences.

Dr. Seitz, we are pleased to have you here. We would appreciate it if you would proceed with your statement.

STATEMENT OF DR. FREDERICK SEITZ, PRESIDENT, NATIONAL ACADEMY OF SCIENCES

Dr. SEITZ. Thank you, Mr. Daddario.

Gentlemen: In appearing before you today as President of the National Academy of Sciences in connection with your review of the National Science Foundation, I would like to focus attention on three matters. First, on the deep importance of the National Science Foundation to science in our country as a symbol of our national maturity as well as a source of funds for science. Second, on the close relationships which the National Academy of Sciences has had with the National Science Foundation. In fact, these associations date back to a time before the Foundation was given official status. And finally, on the Foundation's foreign activities which are closely related to the interests of the National Academy of Sciences.

Whenever the status of the National Science Foundation is under review, it is important to realize that it is at present a unique Federal agency, having no counterpart. Its main goal is the support of basic sciences, quite independent of any immediate practical goal or mission the sciences supported may have. Thus the position of the National Science Foundation is quite different from that of the National Institutes of Health or the agencies of the Department of Defense, the Atomic Energy Commission, and the National Aeronautics and Space Administration which support research. In creating the National Science Foundation our Federal Government for the first time gave official recognition to the fact that general basic natural science is sufficiently important to the national welfare, inde-

pendent of the immediate foreseeable practical results which may emerge from science, to merit Federal financial support. The creation of the National Science Foundation indicated that our country had finally become of age in the era of science. In the appreciation of science as a social force, we had finally pulled completely abreast of our European cousins after lagging since our country was founded.

I would like now to paraphrase several pages of historical material which I think is worth emphasizing at least once in these hearings. Science, as we know it today we call Western science although it is becoming worldwide, has grown through evolution, somewhat like a biological evolution, the evolution of man or some other biological organism, and that evolution has extended over about 5,000 years. Most of the great civilizations of the past which feed into our own have had some body of knowledge that can be called science in their terms, usually centered about studies of the physical world in which we live, and it was usually either used for religious or technical purposes.

We look at what might be called the science of most of the older civilizations, however, we find it surrounded by mysticism and often superstition, although some remarkable results were obtained. As you know, some of the ancient calendars are even more accurate than the one we use every day for normal household purposes. The first time in this stage of evolution that science began to resemble something that we today call science occurs in the Greek civilization. The Greeks starting about 1,500 years ago focused on what we call science, and were remarkably successful. All of us study Euclidian geometry when we are in high school, it is a very eloquent, logical body of scientific nature. They had a number of other successes, the work of Archimedes on floating bodies and some astronomical success.

However, the Greeks in their approach to science had two major drawbacks which we can recognize clearly today with the advantage of hindsight in our own successes. There was a tendency for pure speculation to overrule observation. In other words, they never tied theory and experiment successfully closely together. They tended to give priority to the views and opinions of great men rather than to what they saw and measured.

In the second place, the society in which the Greek scientist lived did not really appreciate the realities of science. They admired the wisdom of the men but they did not appreciate how useful science would be in everyday engineering problems. Had they appreciated this the history of the world may have been quite different. Our ancestors in Western Europe brought science back to attention in the 15th and 16th centuries. They were, of course, stimulated by reading the Greek scientific books, and they were greatly affected by them, but they induced a quite different spirit in the attitudes toward science stemming from the fact that both the scholars of those days and the nobility had very deep practical roots, they were close to the soil and they were looking for things that would be useful in everyday living. They had three new concepts, speaking broadly.

First, they recognized that if they were to make progress they had to tie experiment and theory together very tightly and let theory be guided by experiment rather than by the minds of men alone. This is the first important principle, that you let your general decisions

be determined by what you see and can measure. It accelerated measurement.

Second, they realized that science could have great practical results. If you examine the writings of the great minds who reflected on science between 1400 and 1600, you will find a whole sequence of men, there is Nicholas of Cusa, one of the early scientific philosophers, there is Galileo, Francis Bacon, they all emphasized that if we learn enough about nature we can use it and bring about a revolution and a way of living, get new tools.

And finally—this is the point I want to emphasize particularly—they recognized that while they were squeezing this body of knowledge in order to get practical results they had to support science for its own sake if they were to build up a body of science that would be complete and general.

I turn now to my text, page 4.

One cannot emphasize too strongly that a very important feature of the great tradition of European science—and here I use "European" in such a way as to exclude "American" for the moment—is that it has placed a high value on knowledge derived for its own sake. The Europeans realized very early that one could not expect to foresee the applications which would inevitably come once one had sufficiently profound knowledge of a field of natural science. This principle was used steadfastly by the Europeans, along with good practical judgment, for many centuries. It was this aspect of their approach to science which eventually made it possible for the Western Europeans to create the worldwide technological revolution of which we are so keenly conscious today. It was this point of view which led to marvels such as antibiotics, atomic energy, and Telstar. Had the Europeans invested their resources only in goals having immediate practical importance, we would be living in a much more primitive world.

The early settlers in our own country, facing an enormous untamed wilderness, had too many hard practical problems to deal with to do much about the expansion of knowledge for its own sake. Instead they focused on the practical consequences of science and were willing to let the Europeans generate the basic knowledge which made the development of science possible. This attitude dominated our scene well into the present century, making us primarily users rather than generators of basic knowledge until quite recently. We produced many great engineers of many varieties ranging from those who built the Panama Canal to inventive geniuses such as Thomas Edison. But until recently we added relatively little to the great body of basic scientific knowledge, which is one of mankind's richest treasures.

Fortunately, the seeds of appreciation of the techniques of generating new basic knowledge were planted very early in our country, as we know from the work of men such as Franklin and Jefferson. As our level of income and our freedom from hardships increased, the desire to speculate on nature began to grow and mature. By the time of World War II we had, particularly in our universities, developed a respectable capacity for basic research, funded in the main through private and State sources.

In fact, this capacity had grown to such an extent by 1940 that it proved to be a critical asset in our conduct of the war and gave our country a new and dramatic realization of what both science and the well-trained scientist could mean to the national welfare. It was this appreciation which led Vannevar Bush and his colleagues to propose in 1945 that the Federal Government create an agency which would support basic science without explicit reference to pre-assigned practical missions and take a place alongside the practically oriented agencies. In taking this step, our American society finally caught up with its European cousins in its appreciation of how to optimize the benefits to be derived from science.

Perhaps the following point of view represents one way of emphasizing the importance of the National Science Foundation in relation to our national welfare:

The creation of the Foundation in 1950 emerged from the realization that our Nation had achieved scientific maturity. The sense of responsibility associated with that maturity required that some of the Federal money to be used for basic science be free from immediate practical restraints. If our Nation values its position among those who lead in science, it must expect to support the National Science Foundation in a balanced and rational way.

In discussing the various categories of program which the Science Foundation supports, each scientist will naturally emphasize somewhat different aspects of that program and the budget associated with it as a reflection of his own interests. I do not desire to underscore my own view at this point in the present discussion. It should be emphasized, however, that the administrators within the National Science Foundation draw advice from a large part of the scientific community when developing the programs and budgets which they propose for the Foundation.

My greatest wish is that when the congressional committees weigh the various components which make up the budget of the Foundation, they will seek advice of the scientific community before giving preference to one component of the proposed budget over another.

I should like to turn next to a discussion of the close relationships which have existed between the National Academy of Sciences and the National Science Foundation over the entire history of the latter. In fact I might point out at the start that the scientific leaders who urged the creation of the National Science Foundation at the end of the war were, for the most part, closely associated with the National Academy of Sciences and had served at various times in their careers in a major way in the activities of the Academy. Still further, my predecessor as President of the Academy, Dr. Bronk, was a member of the first Science Board of the Foundation and was its Chairman for a number of years.

Thus the Academy has had a deep interest in the welfare of the National Science Foundation and its programs from the initiation of the latter. To complement this, the Science Foundation has, throughout its history, supported the Academy in its official position as adviser to our Government whenever the issues involved in our advisory work have been closely parallel to the programs of the Foundation.

It would take me a very long time to describe in any degree of detail all the programs in which the Science Foundation and the Academy have worked in close cooperation. As a result, I shall take some of the larger and more dramatic instances. The following cases deserve specific mention:

Mr. DADDARIO. Before you get into these, I wonder if you could go a bit further into the relationship which exists between your organization and the National Science Foundation. You stress that Dr. Bronk was a member of the first National Science Board and was its Chairman for a number of years. Should it be this way? Should there be this close relationship, or would it be more valuable to the Academy and the National Science Foundation to be distantly separated? Would this assure more objectivity?

Dr. SEITZ. I don't have any strong opinion on that, Mr. Chairman. I think that during the period of growth of the Foundation there was a considerable value in having that close tie. At the present time, we have excellent working relations, what might be called at the staff level, and when matters require decisions somewhere near the top, we have a meeting with the Directors of the Foundation and some of the people who work with him in his executive office to straighten out the details and set policy, and that works very well. At present I don't see any rigid need for a tie in an ex officio basis because we do have good relationships.

Mr. DADDARIO. You have said that the congressional committees should seek the advice of a scientific community before giving preference to one component of the Foundation's program over another. Do you believe that the close relationship which the Academy has with the National Science Foundation is a good way to formulate this opinion, and a good source for the Congress to look to as it seeks advice?

Dr. SEITZ. It is one of the good sources.

Mr. DADDARIO. The fact that you do have people on the National Science Board allows the Board to sort of act as a bridge across which some of this advice can come: that is, from the Academy to the National Science Foundation and then to the Congress?

Dr. SEITZ. Yes. Several members of the Council of the Academy and also the Committee on Science and Public Policy serve with the Science Board of the Foundation. I reviewed this matter with the Director of the Foundation, for example, before we appointed Dr. Brooks. And he felt there was no conflict of interest as long as the issues discussed were general policy matters, that affected the welfare of American science as a whole.

Mr. DADDARIO. So if there are matters which you believe affect public policy and questions of appointments, this is discussed and determinations are made which in your opinion, at least, is in the best interest of the entire scientific community?

Dr. SEITZ. That is right. The present working relationships, in which we have no ex officio representation on the Science Board, are working well.

Mr. ROUSH. Are you suggesting by your statement that your greatest wish is that the committees of Congress use the scientific community, and that we are not adequately now using the scientific community in making decisions which relate to areas of science?

Dr. SEITZ. Well, I have felt over the years that the Science Foundation has generally presented what I might call balanced budgets to the Congress, and naturally the overall sum has to be determined by the state of our economy and things of that kind, but there have been occasions when one part of the budget was given preference over another, and I feel that it would be wise to have some consultation with the scientific community at such times, that the decisions affecting the balance of the budget of the Foundation ought in general reflect the opinions of the scientific community as well as they must the opinions of those in Congress who sit on the committees.

Mr. ROUSH. I think we would agree with you on the importance of the Congress consulting with the scientific community in reviewing a matter such as the budget of the Foundation. You have indicated the Foundation has consulted with the scientific community through the National Academy of Sciences in preparing its budget. Are we then not duplicating what the Foundation has already done if we proceed to consult again with the Academy on the same matter?

In other words, would we receive new information?

Dr. SEITZ. One might get points of view that hadn't been completely stressed. I think it depends on the instance.

Mr. BROWN. Let me ask this: Is the National Academy of Sciences necessarily the only spokesman for the scientific community?

Dr. SEITZ. No; far from it, we are just one of a number.

Mr. BROWN. Is it then possible that perhaps Congress should broaden its search for a voice from the scientific community beyond that which the Academy might represent?

Dr. SEITZ. Yes. I think I would emphasize the value of a plurality of opinions. We try to be right in rendering advice in the Academy. We do our best, but we recognize that there are members in the scientific community that sometimes have different views and they should be heard.

Mr. BROWN. I must confess that I don't have a complete understanding of just what constitutes the scientific community, and who might constitute its authorized spokesman. Perhaps we ought also to explore that in a little more detail during the course of these hearings. That is all that I have right now.

Mr. DADDARIO. Any further questions at this point?

Will you proceed, please, Dr. Seitz.

Dr. SEITZ. I might mention the following items in which we have worked very closely in cooperation with the Foundation. There is the International Geophysical Year. It was an 18-month study, extending from July 1957, through December 1958, of geophysical phenomena associated with the solid earth, the earth's surface, and the atmosphere. It was conducted during a period of relatively strong solar activity, when the disturbing effects of the sun on the earth's magnetic field and atmosphere are at a maximum. The program was carried out on a worldwide basis with the cooperation of the scientists of some 66 countries having scientific facilities for geophysical research. Planning of the U.S. participation, and the conduct of our ties with the efforts of the other countries, were the responsibility of a group of distinguished scientists appointed by the Academy. The program was one of unprecedented scope in international science. It could not have been carried forward without the

fullest participation of the Federal Government, both in its scientific planning and execution and in its financial support.

The National Science Foundation was the focal point for the Government's massive effort in support of the IGY. While hundreds of scientists from every part of the United States were involved, the large burden of scientific staff work that made their efforts fruitful was carried by the professional staffs of the Foundation and the Academy. The IGY represented a new level of cooperation in basic science between governmental and nongovernmental agencies and institutions. The partnership of the Foundation and the Academy was essential to its success. Very great benefits to science and our understanding of our environment resulted, which have led to major further international cooperative efforts such as those of the International Years of the Quiet Sun, now in progress during a period of minimum solar activity (calendar years 1964 and 1965).

This Committee of the Academy is perhaps best known to Members of the Congress because of the recent report, "Basic Research and National Goals," prepared under its direction in response to a request addressed to the Academy by the House Committee on Science and Astronautics through its Subcommittee on Science, Research, and Development.

A number of other important studies have been prepared by the Committee on Science and Public Policy, which was established by the Academy in 1962 on the recommendation of Dr. Detlev W. Bronk and Dr. George B. Kistiakowsky. They saw the need for a committee that could provide leadership in the analysis of the status and needs of broad fields of science, and could advise the Federal Government or others on the most promising directions for future research. Some of the funds for these studies have come from nongovernmental sources, including the Ford Foundation, the Sloan Foundation, the American Chemical Society, and the Population Council, but the major portion of the Committee's support has been provided by the National Science Foundation, which is deeply interested in the outcome of such reviews. The Foundation has followed closely the Committee's study of Federal policies and practices in the support of basic research in institutions of higher learning and its reviews of facilities needs for ground-based astronomy, of the uses of computers in universities and colleges, and of needs and opportunities in the fields of chemistry and physics. Similar undertakings are being planned in mathematics and biology. Conducted by panels of specialists in whatever field is involved, and critically reviewed by the Committee on Science and Public Policy, such studies are designed to bring before the Foundation, or other agencies, the carefully considered views of the scientists with regard to the needs, opportunities, and relative priorities in each field on which attention is focused.

The suggestion that it would be desirable to drill deeply into the earth's crust with the hope of obtaining fundamental scientific information concerning the transition between the crust and the mantle was first made by an informal group of earth scientists who were later organized as a committee of the National Academy of Sciences. The National Science Foundation took a major interest in the program from the outset and provided funds and support for the first

experimental drilling in the deep ocean, which was carried out off the coast of lower California under the closely shared jointly responsibility of the Foundation and the Academy.

In the period since 1961, when the first phase of this program was completed, the National Science Foundation has taken over full operational responsibility and the Academy has resumed its more traditional position of serving as a scientific and technical adviser on appropriate aspects of the undertaking.

Both the Foundation and the Academy have been interested in the evolution of reference tables of scientific and engineering data from which investigators and engineers can obtain authoritative current summaries of available data. With the Foundation's support the Academy has been able to call upon the advice of leaders in the several fields of science and technology involved.

Out of this joint interest and endeavor has recently evolved the new and highly important national standard reference data program of the National Bureau of Standards, to which the Academy is engaged in a study of this subject in order to determine how efforts can best be directed toward the realization of practical systems.

Mr. VIVIAN. I would like the privilege of interfering with the smooth continuation of our speaker's efforts on this particular subject. It is of particular interest to me.

As a person who has learned several languages, poorly, I must admit for the purposes of translating foreign scientific journals, I am well aware of the need for efforts such as you are proposing. However, I think perhaps it would be well if you would go beyond this step. It is not just a question, in my mind, of translating a particular language, I think there is possibly a much greater step which the field of science can take and which may have a future impact on the field of international relations. This is what I will call the continuation of the fond and faithful hope which Esperanto represented; namely, that there would be an international language. The evidence of nationalism throughout the world suggests that it will not be an easy task. But fortunately we may be able to refer to the new god of science to establish a new language, because certain of the languages of the world are far more easily automatically translatable than others. In particular, if we could arrive at a tonal system, that is to say an alphabet which was more uniquely distinguishable by automatic detection devices, in other words, pattern recognizers or correlation devices, we could almost surely arrive at a language which was not only automatically translatable with fair ease, but also which would be fairly easily automatically transcribed. I must admit we might lose a certain fraction of our employed people by no longer requiring stenotypists and secretaries but we could at least conceivably reduce enormously the number of people engaged in the sheer handling of words.

I think this is a realistic possibility which could have enormous impact on international affairs. If we could convince people, for example, in French Canada that the retention of the French language is no longer the maximum goal of life, or people of the Far East that their own dialects are no longer the maximum requirement of welfare, we might conceivably use, as I say, the pressure of science to break down some of the most troublesome international problems.

This is obviously a task that will not be accomplished in 5 years or perhaps even 50, but it does have significant economic value and it does have significant international value. I would only comment that if the National Science Academy could in some way promote the establishment of a new machine translatable alphabet and language, it might accomplish a very great benefit for all of us. It would then be up to those of us who are in Congress to find some way to induce large portions of the world to learn this language. I think the fastest way to induce them to learn this new language is to have a machine with an on-off switch that is capable of replacing—I hesitate to say secretary, because that brings into mind the image of an attractive secretary and this might not be replaceable—but replacing much of the very expensive and basically unproductive clerical machinery of offices throughout the world. That is a sufficient comment for the moment. Thank you.

Mr. WAGGONNER. I have one comment, Mr. Chairman.

I think this would require more than that complicated machinery, and he is quite optimistic if it can be done in 200 years.

Mr. VIVIAN. I think it is technically feasible in 3 or 4 years, but I don't think it is internationally feasible within that time.

Dr. SEITZ. As you know, there is a great deal of interest in translation on the part of companies which developed computers. We are still at the crawling stage. We are trying to decide in what direction we shall walk when we can walk.

Mr. VIVIAN. But generally the languages are inappropriate for the tasks being proposed.

Mr. DADDARIO. Have you gone as far as you need to go on that subject?

Mr. VIVIAN. I think if I can only plant the idea successfully, it may have fruition 4 years from now.

Dr. SEITZ. Normally, in the Academy, when someone delivers an opinion such as that we soon put them on a committee.

Mr. VIVIAN. I am safe.

Mr. DADDARIO. I can see no reason why Mr. Vivian could not serve on such a committee.

Dr. SEITZ. I will keep that in mind.

The Foundation conducts extensive fellowship programs that have enormous importance for the health and steady progress of science. In addition, the able staff of the Foundation carries on a program of analytical studies of the way in which trained manpower and financial resources are distributed and employed in the structure of our scientific and technological endeavor. Although the Foundation must incorporate within its own offices a strong staff for the study of the professional training and development of scientific investigators, it looks to the Academy, which has had long experience in the evaluation of fellowship applications, to maintain a study of selection techniques and to mobilize leading scientists and engineers in widely representative reviewing committees to advise on the actual selections. At the present time, the Academy, each year, draws several hundred scientists and engineers into this crucial task.

A number of fields of science deserve continuing study by a committee because they are in a state of rapid evolution and require

program guidance. In many cases the National Science Foundation has called upon the Academy to establish and sustain such committees. Whenever this is done, the staff of the Foundation works in close cooperation with the Academy to determine the general way in which the study should be carried out. Examples include the Committee on Polar Research, the Committee on Atmospheric Sciences and its Panel on Weather and Climate Modification, the Committee on Radiofrequency Requirements for Scientific Research, the Committee on Fire Research, the Committee on the Alaska Earthquake, the Committee on Water, and the Space Science Board.

The Space Science Board works closely with NASA, of course.

Let me turn next to international science.

The Foundation and the Academy form a partnership in the study and development of many international scientific programs, collaborating so as to provide both structure and substance to the role that American scientists and scientific institutions play in international scientific affairs. The benefits to American science derived from this partnership are numerous, varied, and in some respects subtle. Taken collectively they are significant in helping to assure that our Nation occupies a position among the leaders in international scientific affairs.

Viewed broadly there are three well-established categories of collaboration between the Foundation and the Academy in international matters:

1. To individual American scientists perhaps the most important cooperative endeavor is the one which centers about the support of international scientific conferences and related programs that are carried on under the formal direction of the various international scientific organizations both governmental and nongovernmental. In this category are included matters ranging from travel grants for individual scientists who participate in international scientific conferences to the planning and execution of our national contributions to the major international scientific programs such as that of the International Geophysical Year, the International Biological Program, and the International Indian Ocean Expedition.

2. The second area of collaboration arises from the common concern of the Foundation and the Academy for the management of international scientific activity in order to provide reasonable assurance that the maximum benefits will be derived from the time and money spent on such work. Thus the Foundation provides financial support on shares with the Academy in scientific support of the U.S. national committees of the several international scientific unions, and of various special international groups such as the Scientific Committee on Antarctic Research and the Scientific Committee on Oceanic Research.

3. Finally, the Foundation and the Academy join in the conduct of scientific exchange activities with the academies of the Soviet Union and some of the eastern European nations. Since such programs are closely linked to matters of official foreign policy, the Department of State enters as a third partner in the planning and development of programs of this type. The program of exchange with the Soviet Union is now in its sixth year. It has not only helped

in the establishment of closer working relations between the United States and Soviet scientists, but has also given us a degree of hope that Soviet-United States scientific relations will eventually come to resemble those among the open nations of the world.

Mr. DADDARIO. Dr. Seitz, on the first page of your statement you refer to the fact that the National Science Foundation's

main goal is the support of the basic science quite apart from any practical goals or mission that the sciences supported may have.

Have we reached the point in the growth of the National Science Foundation that it ought also to become involved with the practical applications of this knowledge?

Would you give us your view on that?

Dr. SEITZ. I would put it this way. I personally would not like to see the Foundation's program determined in any massive way by immediate practical programs, for example, by some of the needs of the Atomic Energy Commission or the Department of Defense. On the other hand, I think it would be beneficial for the various agencies to have channels of communications of such a type, for example, the Department of Defense would very early know of results that come out of the work supported by the Foundation that could be of use to the agencies which have applied missions. Actually, that is being done on the whole quite well. Organizations like the Office of Naval Research which would historically have close ties with the Foundation do keep an eye on the activities of the Foundation. There are many, many informal connections. I think the main thing I would say is I wouldn't like to see a radical change in the policies governing the support of the Foundation as a result of pressure in applied work. I think we would lose something else.

Mr. DADDARIO. If we are to confine ourselves for the moment to the National Science Foundation continuing to work in the basic research area, you indicate that the transfer of the knowledge to the mission-oriented agencies could be improved. Would you go into that further?

Dr. SEITZ. I will put it this way. I think the staff of the Foundation itself is excellent, do their job as well as they can within the ordinary human limitations. What I think is needed in order to make certain that we get the maximum practical results out of the Foundation is to make sure that the agencies with missions keep strong groups within them that are knowledgeable in the areas of basic science. You sometimes hear it said that perhaps we ought to give responsibility for all the basic science to the Science Foundation. I think that would be a mistake. I think the Department of Defense needs people in it who have programs of superiority for areas of basic science that definitely have applied interests to the Department of Defense, the same within the NIH, NASA, and so forth, so that they will have bodies of people who will recognize quickly discoveries that are made, for example, by those supported by the Science Foundation that are important to their missions. I don't think we should try to tie all of the basic work to the Foundation itself. We should keep it strong in this mission of evolving science but also make sure that there are excellent people in the

mission-oriented agencies. We have some great men, of course, in those agencies. We should keep them strong.

Mr. DADDARIO. Then your recommendation is that basic research be continued in the mission-oriented agencies, and that this not only creates new knowledge but also develops within each of the agencies a competency which it ought to have?

Dr. SEITZ. That is right. My memory goes back to the period 1938 and 1939 when we were making the first buildup in our armed strength. At that time the War Department, I guess it was called then, was very, very far removed from basic science. I would hate to see us go back to that period where there were very, very few distinguished scientists in the agencies.

Mr. DADDARIO. When you talk, Dr. Seitz, about supporting the National Science Foundation in a balanced and rational way, what do you mean by that? Are we doing it now, and what do future trends appear to be to you?

Dr. SEITZ. I think the largest concern I have personally, and I believe many of my colleagues in the Academy's advisory committee would feel the same way, relates to the support of what I call the independent scientist. There are in our country many scientists who carry on research in a modest way. I detect certain forces at work to keep the overall support for that group of scientists at a level at a time when the number is growing because of the expansion of educational programs. I hope we will keep what Dr. Kistiakowsky calls "little science" well funded. I don't think there are so many of these individual investigators that the expense is significant in our national budget. But there is a tendency for the very large programs to put pressure on that may cause us to cut back on the support of "little science." I think that would be a dangerous situation.

Mr. DADDARIO. Is this concern indicated by the advice the National Science Academy's committees gave to the National Science Foundation when it made its budget?

Dr. SEITZ. Yes, I think the proposed 1966 budget of the Science Foundation was very well balanced in this respect. It reflected opinions of many individuals, both in this respect and in respect to matters related, for example, to geographic direction, which is also of concern to us.

Mr. DADDARIO. You refer to the fact that the National Science Foundation does draw advice from a large part of the scientific community in developing its programs and budgets. Could you go into that in some detail? How does it work? What are the mechanics through which this advice generates itself?

Dr. SEITZ. Well, the Foundation, in addition to having its Science Board, which is representative in a broad way of both the scientific and the scientific administrative community, has various panels that are advisory to its own structure in various fields of science. I served for a number of years, for example, on the committee or panel in the field of mathematics, engineering, and physical sciences. It has advisory groups of that kind. Then, as I mentioned, it turns to the Academy committees. We have some 5,000 scientists and engineers that generate the reports that we prepare. It cuts very deeply, not

merely into the academic community but also the industrial community and governmental scientists. I think those are, perhaps, the main sources of advice, although there is, as you know, within the executive structure a great deal of flow, frequently, from PSAC to the Science Foundation or the Office of Science and Technology to the Foundation, because of the Federal Council within the Office of Science and Technology which reviews scientific matters. It is quite an extensive body.

Mr. DADDARIO. Dr. Seitz, you said that, prior to World War II, we had developed a respectable capacity for basic research, funded mainly through private and State sources. What is the danger of those sources shrinking as Federal participation gets larger? Are there any dangers, or is it growing in proper proportion to the Federal funds?

Dr. SEITZ. I think it is definitely growing in proportion to the Federal fund, and, remarkably enough, the Federal support has had a profound effect, for example, on alumni bodies. The average university president gets much more money from the alumni association than he did, for example, before the war. The State budgets are growing for higher education and correlated research somewhat in proportion to the Federal budgets. I think the Federal money has had a catalytic effect completely across the board.

Mr. DADDARIO. Rather than seeing a danger of Federal domination, you see the course of events as one of fairly good balance at least?

Dr. SEITZ. I would say there is excellent balance at present.

Mr. DADDARIO. Mr. Roush.

Mr. ROUSH. Dr. Seitz, I am very much interested in the small college or university. I have five of them in my district, and I serve on the board of trustees of one of these colleges. Three of the five colleges in my district have recently constructed new science facilities, and yet there is very little basic research taking place in these colleges and in these facilities. It has occurred to me that there are certain types of endeavor which could take place in a moderate facility such as we have in these schools, but the great difficulty we have is in paying a salary which is sufficient to attract a man who might be doing basic research into the small school. They tend to migrate to the larger universities where they may have a lesser position but still are paid more money. Have you given any thought to this, or would you care to comment on this, which is a problem to me?

Dr. SEITZ. I recognize the problem. I must admit that I don't see a simple solution to it, particularly in the fields of science. As science evolves, it inevitably requires more and more sophisticated equipment. As one probes deeper and deeper into nature, the equipment becomes more complex. It must be so. The string and sealing wax days are gone. The small colleges are at a disadvantage in procuring such equipment. In some cases, relationships can be established with the bigger universities and the staff, if they are in proximity, can use facilities in their spare time. I don't see any simple solution to it.

Mr. ROUSH. I would guess that there are probably 5,700 students in these 5 small schools. Out of those 5,700 people, I would imagine

there are several very bright young people who are interested in science, but maybe because of a church relationship or because they can't afford to go away to school, they are stuck in this small school, and this talent may be lost forever.

Dr. SEITZ. I note that a number of the colleges which once were regarded as 4-year schools are now adding graduate departments. I am thinking, for example, of Dartmouth and others. I have a feeling that somehow that must be the future for many of them, perhaps by joining together in a shared program, something like the Claremont group on the west coast, some specialization which allows the addition of graduate programs, graduate students and the acquisition of those things which you can have when you have graduate programs.

Mr. ROUSH. Thank you.

Mr. DADDARIO. Mr. Vivian, any further questions?

Mr. VIVIAN. No questions.

Mr. DADDARIO. Mr. Chairman?

Mr. MILLER. No, but I would like to say I am very happy to be here and to see Dr. Seitz. I appreciate the great contribution that he has made in his position, and the great assistance that he has been to this committee. I am always happy to see him.

Mr. DADDARIO. We are pleased to have you here, Mr. Chairman. I know you have come because Dr. Seitz and Dr. Waterman are our witnesses this morning.

Mr. YEAGER. Dr. Seitz, recently you had occasion at Purdue to discuss the project system in relation to the institutional grant. I wonder if you would care to comment on that to the committee, or give us the gist of that discussion? Is it in balance at the present time; is it a situation that can take care of itself; might it be improved, or any comments you might have in that area?

Dr. SEITZ. Let me hasten to say that some of my friends regard my points of view expressed at Purdue as somewhat controversial, that is, not everyone in the Academy agrees with me completely. On the other hand, there are those who do.

The project system has been a wonderful thing and I think we want to continue it. There will be instances in which an agency recognizes that an individual on an institution's staff is so distinguished that it will want to select him out and give him money directly. I didn't at Purdue advocate the abolition of such direct support. I believe, on the other hand, that if you have an entire institution which is distinguished it would, in my opinion, be wise for both the agency, for example, the Science Foundation, and the institution to agree that they will provide institutional support which the university will then distribute to its staff in relation to their needs, using the faculty and the administration as a team. I have seen that work. At the University of Illinois there is a research board which distributes certain money which comes to the university from the State and some of it in the form, of course, of institutional grants. The members of the board sit around the table and analyze the proposals from the faculty members. They do it wisely, amicably, and I think it can be done in many universities. What would result would be a certain economy in the process of decision. I think in addition it is wise for the university to learn to do that. I guess if

I were asked to make a recommendation, and I want to emphasize that this is a personal opinion, I would like to see about half of the money handled by institutional grants and perhaps half on the project system. But there are those who disagree with me.

Mr. DADDARIO. Dr. Seitz, I want to thank you for having appeared before us this morning and for the advice you have given us. I hope we might be able to send some questions to you to be answered for the record.[1]

Thank you very much.

Our next witness is Dr. Alan T. Waterman. We are pleased to have you here this morning, Dr. Waterman. The committee is privileged by your presence. We have over a long period of time on this committee looked to you for guidance and advice. The fact that you were the first Director of the National Science Foundation brought you into close proximity with this committee for many years.

STATEMENT OF DR. ALAN T. WATERMAN, FORMER DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION

Dr. WATERMAN. It is a great pleasure to be here, Mr. Chairman, not only because the subject is one in which I am still extremely interested, both from the standpoint of science in general and also the NSF, but also to associate with you briefly again on affairs of mutual interest.

May I say that I have always appreciated the work of this committee, Mr. Miller, the overall chairman, and yourself in the intelligent approach you have always taken with respect to the activities of the Science Foundation. It has always been very valuable to us.

On this occasion your very thorough review seems to me a very timely thing. There are many questions floating around concerning what the country should do about research and technology, the sums of money that should be invested, and how much the Federal Government should participate. These are serious questions; they should be reviewed and understood. In fact, I think one of the most important things we can do about science today is to see that these matters are much better understood by the public generally and, of course, by the scientific community, industry, and government.

Since my printed testimony, Mr. Chairman, is on the long side, if it is agreeable with you, I will just give a synopsis of this, following the general outline but bringing up the topics somewhat differently.

Mr. DADDARIO. That will be fine, Dr. Waterman.

(Dr. Waterman's prepared statement appears at the conclusion of his remarks.)

Dr. WATERMAN. In the first place, I would like to endorse what I believe has been said by many others—and I think what your committee may also feel—that the National Science Foundation Act has served very well indeed. It is a tribute to the Congress in the first place that an act should have been devised of this character, breadth, and flexibility. In my opinion this is exactly the way that

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

science affairs should be handled in the Government, and it was a real step forward when the Federal Government decided upon this particular way of dealing with the subject.

In the National Science Foundation Act—I am not going to go into its details; you know the history, of course, very well—I should like to call attention to two points where there has been some misunderstanding and where I believe the solutions have been good.

In the first place, because of the breadth of the National Science Foundation Act, it was possible for the Foundation to make decisions with respect to its programs and policy from the very beginning, with the assistance, of course, of the administration and the Congress. One of the first things which we decided—all of us—was that the Science Foundation should not monopolize the support of basic research. This was an important step because at the time there was considerable pressure to do just that. This was settled by Executive Order 10521, in 1954, which was worked out by the Foundation with the Bureau of the Budget. Essentially this stated that basic research should be authorized and supported by Federal agencies concerned with research and development but that this basic research should be closely related to the practical mission of the agency. This policy has withstood the test of time very well, and, as Dr. Seitz has already testified, I believe it to be extremely important. No general outside agency such as the Foundation can do as much special research as, say, the Department of Defense, NASA, or the Atomic Energy Commission require.

This means that in its role the National Science Foundation should be aware of what basic research is going on in other agencies and complement that by its own program, and, of course, go into the fields which are far removed from the practical, so as to achieve a good comprehensive program for Federal support.

The second point about the act was one which stated that the National Science Foundation should evaluate the research programs of other Federal agencies. At the very beginning when I was asked if I would serve as Director I wanted that clarified, because I do not think it would be proper for an agency on the same level as other agencies to attempt to evaluate and supervise their programs. This leads to a division of authority. Practical agencies have reasons for doing basic research that would not be the Foundation's reasons, and I did not think, and still do not, that this kind of evaluation is a desirable thing for the NSF to attempt.

On the other hand, the interpretation which I put on this is I think valuable. Perhaps more could be done with it; that is, the Foundation should find out what is going on in other agencies in the support of basic research by fields of science—physics, chemistry, mathematics, biology, etc. Then if one puts together the agency programs in the field of physics, in the field of chemistry, and so on, one can by means of existing advisory committees and with the help of the National Academy, if desired, survey these and evaluate them as Federal programs in science. That is a very different matter from trying to criticize agency programs as such.

Now, obviously the Science Foundation cannot do this alone; it requires other agency cooperation. It already does, as you know, study the basic research support in other agencies, publishes the

amounts which are spent among them in the different fields of science, and has a planning and analytic office to study these matters. This is a very important thing to do. Accordingly the second point about the NSF responsibility is, then, that it should evaluate science programs and not agency programs. Agency programs should be evaluated at a higher level.

Of course, to bring this up to date, we now have for coordination the Federal Council for Science and Technology, as you know, and also the Office of Science and Technology, both at a higher level; they can go into the review and evaluation of the programs of other agencies as such.

The Foundation I know still carries on close associations with the other agencies in the fields of science, so that responsible science administrators know one another, compare notes and cooperate as Dr. Seitz has already said.

Mr. DADDARIO. Would there need to be a new mechanism added to the present process of evaluation so that it would be possible to get a complete picture of science?

Dr. WATERMAN. This is the kind of thing now which the Academy Committee, headed by Dr. Kistiakowsky, is actually doing. Their information about what agency programs in science comes largely from the National Science Foundation and from the agencies themselves where this needs further elaboration. When one is going to make a thorough review, this ought to be done by a top committee. But in the interim between such reviews my view is that the Foundation's staff in association with the staffs of other agencies can review what is going on in Federal support of science. By the same token, as came out in your discussions with Dr. Seitz, if anything useful should come out of the research programs of the Foundation, this close association will enable the interested agency to pick it up. This does not call for a new mechanism, but only closer attention to an existing one.

An important question right now, perhaps the most important of all, is the optimum magnitude of Federal support of science. In trying to answer this, one has to define clearly what one means by a scientific program. That is a familiar topic to you. It involves the distinction between basic research, and applied research and development. These are overlapping areas, but the distinction in principle is clear. For the record I would like to sum up the differences; they are about as follows. In basic research one gets the source material for applied research; one gets new ideas. One gains increased knowledge and understanding of man and the world he lives in. It is by means of basic research that the advanced training of scientists takes place. Thus it is a most important activity of the colleges and universities, which are the source of our trained scientists. Its motivation is different from that of applied research and development since in basic research one seeks merely to find out something which is new and original. It is a very strong one. This motivation for discovering something original means that there is a built-in mechanism for coordination in basic research. That is to say, if as a research scientist I try to discover something completely new in the field, say, of cosmic rays, how can I know whether what I am trying to do is original unless I know what others are doing? And

they are all in the same boat. Therefore, we must communicate in order to know whether what we are trying to do is original. This is a very strong means of coordination and prevention of unnecessary duplication in the case of basic research; one can count on it. This does not mean that overall coordination should not take place among agency programs, and the Federal Council for Science and Technology was established to deal with this. For another point basic research is essentially unpredictable since it lies in the unknown, and since it is remote from ordinary practical affairs, its scientific value must be judged by scientists themselves. All of this means that basic research for scientific progress is best handled by an agency which is devoted to that special purpose.

In the case of applied research and development, there are great differences. In the first place, there are practical objectives which are specific and these objectives can be evaluated. The purpose should be known, its priority, what the undertaking will cost, whether it is worth the cost, whether it is feasible, and whether if the development is successful it will actually achieve the objective which gave rise to it. This must be judged by a large number of experts, not merely scientists and engineers, and it becomes a very complex problem. Applied research and development are properly the responsibility of special mission agencies like Defense, the Atomic Energy Commission, and the National Institutes of Health.

Actually, a good basic research program, as I have often said, is really an investment, and one wants to make it as sound as possible. As in an investment some of the projects you would call "sure" things, where the return will not be large, but it will be there. There should be others where the possible return may be very large but they are greater risks. If such one comes through, however, it will pay off handsomely.

As you know, industries have come to count on basic research in their own research departments, and when they do, they take this statistical view, too. If I remember correctly, one technical firm, for example, counted regularly on 15 percent of the money spent in basic research coming through and enabling new products for the company. That was enough to more than pay the cost. So, the investment may be sure, but where precise returns are going to come, you do not know in advance.

Actually, if scientists were to specify a most satisfactory program in basic research, they would probably advocate support of all competent scientists in their respective fields, the criterion being competency. This is the best way to uncover new knowledge wherever it may lie, to add to our source material for possible use and to be sure that we overlook no bets.

How close do we come to this degree of support? In present practice, this depends on the availability of funds and whether the scientific community know where to go for support. By now they know pretty well where to go. An approximate figure for the entire group of Federal agencies would come not far, I think, from the Foundation's figure: about 50 percent of the number of applications receive support, but at the present time only roughly 25 percent of the total amount of money asked is available for obligation. This means that there is a high degree of selection, a principle which I

believe is wise. But the amounts of money which are awarded do not measure up to the amounts that were asked. This can be serious. When a proposal is cut which has been carefully and conscientiously worked out, it may cause severe damage to the project. Admittedly, there are some proposals that should be cut; this is part of normal administration. But at the present time my general criticism would be that in agency attempts to improve program coverage, grants and contracts for basic research fall too short of the funds requested. As you can see, if it becomes known that agencies make a regular practice of cutting project budgets, there is a great temptation for an applicant to put in a budget that is larger than he needs so that when it is cut he gets what he wants. That is not a sound policy.

There has been much said about the distribution of basic research and research support in general throughout the country. I know that you have made a special study of this, too, I simply wish to point out that the distribution of the National Science Foundation research grants corresponds quite closely with the distribution of active research scientists throughout the country. That seems to me to be a rather fair way of doing it. What I would especially like to point out is one which to me is a very satisfactory way of dealing with this subject. One should make quality the outstanding characteristic in the selection of basic research for support. This is largely a subjective judgment, and one does the best one can. When an agency evaluates a large collection of proposals, there will be a few of outstanding quality. Obviously these should be supported wherever they are. There will be a lot that are excellent and very good. These, too, should be supported wherever they happen to be. Now, as one comes down along the rating of quality, one reaches a level where one has to cut off for budget reasons. One will find there a large number of proposals, all of about the same scientific quality, from all sorts of research fields and types of institution, large and small, young investigators, senior ones, and from different regions of the country. There is the place that the agency can pick and choose. The Foundation's practice in the past has been to select at that quality cutoff level proposals favoring remote regions, young investigators, small institutions, and so forth. Now, there is the region where one can make adjustments without sacrificing quality standards. If this is sound procedure then on receiving more funds, the Foundation could readily make wider distribution of them and correct a general trend which has been often called into question. I would just mention briefly——

Mr. DADDARIO. When you say it is a trend which is called into question on occasion, do you mean that it is proper that more be done in this area?

Dr. WATERMAN. I believe so. I think this is the way to do it. I don't think it should be done with any sacrifice of quality.

Of course, one has to realize that the agencies with practical missions do not have this objective. It is not really their business. They must get research results which are going to help them in their missions. So one finds the large agencies, generally placing their research where the highest competence lies so they can get a return for their money just as industry would do. The result is they don't

distribute their funds so widely, and I don't think they should. The Foundation can do it.

The other point I want to make in this connection is that I believe the NSF should have a larger proportion of Federal basic research funds for disbursement to academic institutions, to encourage research training and breadth of research support. I believe that according to the latest complete data (1963) NSF provides less than 30 percent of the Federal basic research support to academic institutions. I believe this should be higher. It would improve the distribution I spoke about; it would also increase the participation and leadership of the NSF in basic research councils within the Government itself. I think that here the Foundation could be of greater help to the Office of Science and Technology, in ways that Dr. Seitz has suggested.

Mr. DADDARIO. How high would you go when you say you should have a larger proportion?

Dr. WATERMAN. This shouldn't be done too quickly. One doesn't want to interfere with the programs that are going well in other agencies, and the Foundation's participation has grown. I should think the Foundation ought to come to at least 50 percent of the Federal support in basic research to academic institutions.

There is another point. In my opinion one has to be careful in supporting basic research that it all does not go into fields which are estimated to be of practical importance. History is very clear on this. Some of the capital discoveries have come in fields that have been neglected. In trying to anticipate the fields in which basic research is going to be practically important, one should not ignore the others. If you look at the overall program for basic research you will find that about 80 percent of the support is provided by agencies with practical missions, which by accepted policy means in fields where they expect results beneficial to them. That leaves only 20 percent for the support of free research—primarily in the interest of science. I think that is too small. This situation too, could be improved if the Foundation had more funds.

I have talked much of budgets, but you will note that the points mentioned are all based on policy principles. I should like now to call attention to the unique character of the National Science Board. It has helped the Foundation greatly in policy determination, in passing on actions, and in furnishing guidance. Since it has on it not only research experts but academic presidents, leaders of industry and men of affairs, it is a unique body in dealing with many of these policy matters. I believe more use could be made of it in the councils of the Government.

Next, I want to mention in passing that the National Science Foundation should continue to have close association with the National Academy of Sciences, with the American Association for the Advancement of Science and other scientific societies. I believe the National Science Foundation should be the colleague in the Federal Government of those scientific agencies. It can work with them on a highly cooperative basis, as for example, in international science programs or in special areas, as Dr. Seitz has already testified in its relations with the National Academy of Sciences.

One point I would like to stress—in the support of basic research, especially in academic institutions, continuity is a very important consideration. It is most disturbing to a university continually to have to jump from one research project to another because of a change in support or to call off scientists from doing one thing to take up something else. These plans have to be made slowly and carefully at universities, and they badly need assurance of stability. Thus continuity of support is a very important matter to them, and I think in this the Science Foundation should be in the best position to assist.

Another important matter is the following. At present the budget process calls for about a 2-year interval before the money is available. That means an agency can only start obligating a particular appropriation after a 2-year interval since its plans were made. As I have said, basic research is unpredictable. Suppose shortly after an agency gets its appropriation a capital discovery is made in basic research, or more than one, as may happen. Immediately the thing to do is to pay special attention to that field, to see that it is cultivated and, if there are any possibilities of exploitation, to let these go forward. But the agency budget planning was made 2 years ago; there is no money for contingencies like this. If some way can be found to provide a contingency fund for such emergencies, this would be a great national gain. I do not know how this can best be done, but I regard it as a very important matter, indeed.

Finally, I should mention the subject of international cooperation in research. In the particular case of very large and expensive installations or programs, we are reaching the point where these are going to be very troublesome in the Federal budget. They are very large; they may be very important. If we don't do them, then we fall behind in world competition. In the case of high energy particle accelerators, for example, if the nuclear physicists say that their progress in the analysis and the understanding of the atomic nucleus can only be advanced by building a new high energy particle accelerator, then what do we do? If we do not do this, we drop back in that field in world science. If we choose to go into it, one good way to economize is to do this with the cooperation of other nations, if this can be managed. On the European scene the organization known as CERN in Geneva is doing a magnificent job in this area, nuclear physics, in a concerted effort with other countries. We have done the same thing with other countries with the IGY and other programs. If space exploration, where the costs are enormously high, could be managed by friendly cooperation among interested nations, it would decrease the cost to any one of them, it would be an additional way in which we could get closer and friendlier association with them, and it would add the world's experts to this difficult accomplishment instead of just one nation's.

Finally, I believe, Mr. Chairman, that above all we must realize and appreciate the importance of what is coming up in research and development in improving our environment, in fact, in creating new environments, in exploring space, in exploring the depths of the oceans and the interior of the earth, in the study of life on earth and what can be done about our natural surroundings. We are making very rapid progress in all of them. It seems to me to be of the greatest importance

in the national interest to further the support of basic research on all these frontiers, and the training of scientists and engineers to do it. I believe that the NSF is the proper agency to take the lead in these matters.

Thank you very much.

(Dr. Waterman's prepared statement follows:)

PREPARED STATEMENT OF DR. ALAN T. WATERMAN, FORMER DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION

Mr. Chairman and gentlemen, I am happy to have this opportunity to appear before you in your review of the policies and programs of the NSF and am very pleased at thus briefly renewing our long and friendly association. As an alumnus of that organization, I have a special interest in the subject. Perhaps I should warn you: Alumni of most organizations are apt to be conservative and resistant to change. However I do not think that applies so much to the former head of an organization; his mind is apt to dwell on situations where his efforts might have been more effective.

Let me say at the outset that I am most grateful for the intelligent interest which I feel the Committee on Science and Astronautics has always taken with respect to the NSF. The reviews of our programs which your committee held were always stimulating and valuable to us.

I shall not take time to go over the history of growth of the NSF and its present activities. This is well known to you and is provided in factual setting and detail by the very complete summary furnished by the report of the Science Policy Research Division of the Library of Congress.

Suffice it to say that by its passage of the National Science Foundation Act in 1950 the Congress went on record as showing its understanding and appreciation of the future role of science in our country. There was special significance in the manner in which this was to be organized and administered—by an independent agency devoted to the encouragement and support of basic research and education in the sciences, together with the development of national policy related thereto.

This action was a far-reaching policy decision and one of great wisdom. For it properly set apart the sponsorship and growth of science from research and development activities directed toward the achievement of practical national goals such as defense, health, atomic energy, space exploration, etc. It also recognized the intrinsic value of science and science education as a national goal.

At the time of its founding there were many who felt that all basic research should be supported by the new Foundation, or in any event that the overall Federal basic research effort should be supervised or directed by the National Science Foundation. Concerning these two propositions: The former was settled, quite properly in my opinion, by Executive Order 10521, in 1954, for which the staff work was done jointly by the National Science Foundation and the Bureau of the Budget. This stated that every agency involved in research and development should have authority and funds to conduct and support basic research in fields closely related to its mission. The reason is simple: A Federal agency with a practical mission, should engage in basic research which provides insight into its applied research and development problems and its future progress and which thus it can defend in its budget. As our highly successful technical industries have amply proved, it is important for an agency to participate actively in basic research and thus get this background at first hand, not solely through outside sources. Furthermore a plurality of sources of support avoids the hazards of monopoly.

The idea for National Science Foundation supervision of basic research programs of other Federal agencies, stems from a natural desire to achieve coordination and elimination of duplication among the 40-odd Federal agencies engaged in research and development. This is a more complex matter. In the first place the executive branch is not organized in such a way that one agency can or should evaluate and report on the effectiveness of the programs of another. The mission of a given agency should be its own responsibility, for which it has had abundant experience and for which it should be held accountable, to the President and to Congress—not to a sister agency.

With respect to duplication in basic research, however, there is a far more fundamental and effective solution than the appointment of a coordinating body. When I say "duplication" of course I mean undesirable duplication, since some duplication is commonly required in basic research in order to check the accuracy of the result of a single research investigation.

Now basic research has a built-in coordination which prevents undue duplication. The advancement of a basic research scientist in his field depends upon the originality and the soundness of his work. His aim is to make a unique contribution to knowledge in his field—something no one has ever done. It is clear then that he must know what has already been done and what others are doing in order to be reasonably certain his work is original. Since his colleagues in his field are all in the same situation they must and do communicate with one another as to their current research. For a basic research scientist to repeat unnecessarily the work of another is to commit professional suicide. This provides the strongest of motivations for coordination; it constitutes the built-in mechanism I mentioned.

While this completely minimizes the risk of unnecessary duplication in basic research, nevertheless the need for coordination among Federal basic research programs is of course desirable. Curiously, the National Science Foundation Act does not mention, except by implication, a Foundation responsibility for coordination of basic research among the Federal agencies involved. It does, however, stipulate that the Foundation evaluate the research programs of other agencies. On this point you may be interested to know that when I was approached regarding the position as Director of the NSF I pointed out that one interpretation of this provision was not feasible nor proper; namely, NSF review and evaluation of the research and development programs of other Federal agencies. In the first place, the competence of the NSF would lie in basic research and not in development. More importantly it was improper for one Federal agency to attempt to evaluate and in that sense supervise the work of sister agencies. My interpretation of how I would carry out this responsibility was accepted. It was as follows: The NSF should take steps to secure information by fields of science from other Federal agencies regarding their support of basic research. Thus the NSF should determine the basic research activities throughout the Government in the fields of physics, mathematics, etc. In this way the Foundation could plan its own research programs to supplement and round out the work carried out by other agencies. Also, with the help of its divisional and other advisory committees, it would then be in a position to evaluate the basic research performed by the Federal Government in each of these scientific disciplines. Accordingly the Foundation began at an early date to collect data concerning the basic research of other agencies. This system has the advantage of bringing together the science administrators of other agencies in their common fields of interest.

One of the fundamental questions of today concerns the optimum magnitude of the overall basic research effort. As a matter of national policy, what should be the present and future levels of support for basic research What proportion of that support should be borne by the Federal Government? By the NSF? This is a subject which, as you know, has been undertaken for the Federal Government by the National Academy of Sciences in its Committee on Science and Public Policy.

The first point to be settled is to know what we mean when we say "basic research." For the record—this explanation being superfluous for this committee—it cannot be too strongly emphasized that basic research must be carefully distinguished from technology. For some reason science is associated in the public mind with military and other highly visible items, such as weapons, aircraft, satellites, refrigerators, TV sets, deodorants, insect killers, and mechanical carving knives. These are of course the end items of a series of steps—applied research to demonstrate the feasibility (in principle), development to engineer and test a practical device for production, and finally production and distribution. One commonly hears such statements as: the country is spending $20 billion on research; the Federal Government is this year proposing to appropriate $15 billion for science. These are serious misstatements. Sums of this magnitude represent appropriations for research and development of which the funds designated for basic research amount only to about 10 percent. If one is worried about the Federal budgets for R. & D., then the place to make any significant saving is obviously where the heavy costs occur—in development

where 70 percent of the expense lies, and its related applied research which adds another 20 percent.

The role of basic research is simply to furnish the source material and the initial ideas for applied research and development. At the same time, in its natural habitat, the colleges and universities, it provides for the advanced training of scientists and engineers, to be available for careers in industry, government, and the academic institutions themselves.

Applied research and development are characterized by having practical objectives, usually quite specific. Their evaluation must include evaluation of the objective, its priority, and its feasibility.

On the other hand: (*a*) the findings of basic research are in general unpredictable, since they lie in the unknown; (*b*) a basic research finding commonly carries with it no connotation of immediate feasibility for practical application.

Thus, Einstein's capital discovery half a century ago of his famous equation, $e=mc^2$ contained the theoretical possibility of the conversion of mass into energy. When asked whether this discovery might some day be put to use he replied that he saw no possibility of this. The key to this hope of feasibility finally appeared with the discovery of nuclear fission in 1937, again in basic research. But practical exploitation came only during World War II by a most elaborate and costly national effort in applied research and development where, as a matter of fact, the issue of practical feasibility was long in doubt.

But there are other and equally important distinctions between basic research and technology. First there is motivation. Generally speaking the basic researcher is out to secure new knowledge and not something directly useful. Thus his search is broader and more likely to result in some addition to our fund of knowledge, always useful to other scientists but not immediately or necessarily to technology. Since his standing and his future in his profession depend primarily upon the originality (and soundness) of his finding, this motivation is very strong.

In examining a basic research program no one outside the field is justified in trying to place a value upon a particular research project by its field or by its title. Such judgments have validity only when made by experts in the field in question; they depend upon the current status of the field and especially upon the competence of the researcher. Besides, as is well known, some of the most surprising and far-reaching discoveries have occurred in little known and unexpected territory. Consequently the review and evaluation of basic research must be conducted by the scientists themselves.

Actually a first-class basic research program is comprehensive in scope and has the characteristics of an investment—some "sure things" of probable small but certain return, and others of high promise but problematical as to accomplishment. Another unique characteristic of basic research bears mentioning: a confirmed negative result has value, in preventing further time and effort on the subject.

Now contrast this philosophy with that of applied research and development. Here one starts with a reasonably clear objective. This immediately raises a number of questions: What useful purpose is the proposed undertaking expected to serve? How important is this objective and to whom? How much will the effort cost in dollars and manpower? Is it worth this investment? Is the proposed plan feasible in execution? If successful, will it actually achieve the objective intended? This indicates clearly that the evaluation of a proposal for an R. & D. undertaking brings in many considerations other than scientific, and consequently the exercise of judgments among many other than scientists, such as administrators, management, manpower and budget specialists, engineers, analysts, technologists, and individuals experienced and expert in industry, business, and public affairs.

This whole matter may be likened to the opening up of a new territory. The comprehensive exploration of the territory corresponds to basic research, the search for mineral or other resources corresponds to applied research, and the study of how these resources may be exploited corresponds to development.

In sum, therefore, basic research programs lie in a category by themselves. The soundness and value of a basic research program can only be evaluated by scientists with high competence and experience in their fields.

What conclusions may be drawn from this? First, a national program for the advancement of science should be the primary responsibility of an independent agency with that explicit mission—progress in science. Such an agency is the NSF. Only in this way can a fully developed and sound basic research pro-

gram be developed and maintained, with the desirable degree of continuity and coverage. In the comprehensive program sponsored by such an agency, account should obviously be taken of the basic research programs conducted and supported by other agencies. But the overall program also should be watched. For example, the basic research program of an agency with a practical mission may overfinance a particular field in the effort to reach an important objective, or several agencies may unwittingly plan to stress research in the same field, thus putting a severe strain upon available scientific manpower and facilities therein and detracting from support needed in other areas of science.

From the standpoint of the progress of science alone, for the desirable level of support of basic research, consensus among scientists would advocate support for all competent scientists in the research they judge to be most promising. The line would be drawn at the criterion of competence—admittedly a subjective one and difficult to judge. In practice, the most feasible way to solve this problem is to provide a level of support which will require competition among applicants for support. Then, provided the availability of funds is well known to prospective applicants, the program should be selective of the country's best research talent. Decisions as to selection must then be made with the advice of research experts. This, of course, is the so-called project system. From all accounts it has worked well and should be maintained. This is a recommendation of the Committee on Science and Public Policy. Notice that this system does not, of itself, introduce priorities as to scientific field—the essential criteria being scientific promise of the research and the competence of the investigator(s). This is consistent with the point of view of pure science—all fields are important; capital discoveries may be made in any of them.

The NSF has had considerable experience with the project system, developed according to these principles. It is generally followed by most R. & D. Federal agencies, with one important difference—among agencies with practical missions, in the selection of the field or subfield supported the relevance of the basic research to the agency mission is an important factor, as is the possibility of valuable applied research opening up as a consequence of the basic research findings.

How closely does the present Federal support of basic research come to complete coverage? On analysis one finds the following. Somewhat less than half of the applicants for basic research proposals are successful in securing funds in the mathematical, physical, engineering, and social sciences and more than half in the life sciences. In the NSF the figure has been close to 50 percent. On the other hand the proportion of funds awarded to funds requested is in the neighborhood of only 25 percent for the physical sciences group above; it is considerably higher for the life sciences, reflecting the greater availability of research funds in the latter area.

While some of this pruning of individual project funds is undoubtedly justified it must also be admitted that as a policy it can do much harm. Many a scientific project is conscientiously budgeted and is severely handicapped by curtailment of funds. Besides, once this practice becomes general, applicants may quite naturally try to protect their requirements by sending in inflated budgets. And one can hardly blame an agency for attempting to cover all worthy requests. At the moment in most scientific fields progress in research and in the training of young scientists is judged to be in serious trouble on this point—adequate financing—especially in the physical sciences.

An increasing complication in attempting to reach an optimum level of support while dealing fairly with all fields of research is the large and rapidly rising cost of certain research areas, usually due to the necessity for large or elaborate installations—notably, high energy particle accelerators, radio telescopes, oceanographic research vessels, and scientific satellites and probes for the exploration of outer space. What makes matters worse is that the maintenance of such installations is correspondingly high. Furthermore, the large amounts required for these purposes involve competition with other national priorities outside of science or drastic curtailment of general research funds.

This difficulty is probably best met by separating out from the general research budget all capital items of this costly nature so that consideration of their financing may be met more directly than by their inclusion in the regular research programs. In the view of the undersigned, a most inviting prospect for reducing this kind of strain on the national budget is to encourage the scientists in the field in question to work out a plan for international cooperation as the European scientists have done in the case of CERN for costly high energy

physics installations. If such cooperation could be secured for research in space exploration by the nations with interest and competence therein, enormous savings in money and manpower would be made by the participating countries, as well as providing a most effective basis for improving international relations.

One of the major questions engaging the attention of the Congress and the country at large is the distribution of research support among the various regions of the country, their industries and their institutions of higher education.

Much has been said about the inequity in distribution of Federal research funds going to colleges and universities. Thus with a total of some 2,100 colleges and universities in the United States practically all funds for research go to less than 400. This is highly misleading. Let me remind you that these 2,100 include a great many special institutions (30 percent) not commonly associated with the usual term higher education. Only about 55 percent of this total, or about 1,150, grant degrees in mathematics, science, or engineering, and of this 1,150 somewhat less than 400 report research activities in science. Furthermore, these 400 institutions include over 99 percent of the country's scientists in academic institutions. Thus, on going beyond this group of 400, one finds only about 1 percent of our academic scientists employed in the remaining 750 institutions granting science degrees; practically all of these are engaged only in teaching, in accordance with the policies of their institutions. Accordingly, the general distribution of funds among academic institutions appears to be reasonable. In this connection one must remember that mission-related agencies must regard as their primary justification for the support of basic research the value of the prospective results and the relevance of the latter to their practical missions. It is not their responsibility to make equable distribution of research funds throughout the country and among large and small institutions. Considerable improvement of this situation would be made by allocating a greater proportion of Federal funds for research to the NSF which does include such a responsibility.

I understand that at present the NSF provides basic research support to some 338 colleges and universities. If one includes educational support which is related to research, the NSF provides support to 850 academic institutions.

In my judgment this is a reasonably healthy situation, providing as it does for a fair degree of competition in order to secure Federal support, whether for research or for special education and training purposes.

As a matter of fact, the NSF has disposed of its requests for basic research roughly as follows: After evaluation incoming proposals can be arranged in approximate order of quality. Those of the highest quality should receive grants regardless of location or type of institution, simply in the interest of progress in science. The current appropriation of the agency necessarily establishes a cutoff point, determined by quality considerations. At this quality level, however, there will be found a large number and variety of proposals from all sections of the country and from all types of institution. It is therefore possible at this level to exercise preferences in favor of small rather than large institutions, young and relatively inexperienced investigators, and to make more equable distribution among different regions. The resulting distribution may then be analyzed, as the NSF has repeatedly done. In general, the results have always indicated that the distribution of support corresponds closely with the active research population of the region. That is to say that the grants are distributed about uniformly among the competent research scientists wherever they are.

If this principle is followed in awarding basic research grants, then it is clear that an increase in the basic research appropriation for the agency would improve the distribution by permitting more opportunities for selective encouragement of small institutions and have-not regions, while still adhering to overall quality standards, and without sacrificing competent research at the larger research institutions.

Considerable thought and discussion have been given in recent years to the distribution of support to science among the universities of the country. This has arisen from the observation that so much of the total basic research support goes to so few universities. A wider distribution would relieve the strain on this latter group and at the same time provide incentive and opportunity for other universities to join the group of leading research institutions. Such a provision was strongly advocated in a report by the President's Science Advisory Committee entitled "Scientific Progress, the Universities and the Federal Government" (1960), which specifically recommended that the number of leading research universities be approximately doubled.

As you know, the NSF has taken steps recently to improve this situation by the introduction of its science developmental program. This is aimed not only at increasing the number of universities just mentioned, but also at improving the scientific capabilities of other classes of academic institutions both large and small. This is a most worthy and timely cause. It must be acknowledged however that to do this selectively, which is the logical and most efficient way to begin, is a highly complex and difficult undertaking. The allocation in the 1966 budget request for this purpose is only a small beginning. However it should provide the NSF with the requisite experience, and evidence as to the most feasible approach. It should be abundantly clear that high standards of quality and promise should be maintained and that again the element of competition be present.

GENERAL CONCLUSIONS

Both from my own experience and from following the excellent progress of my friend and successor Dr. Haworth (assisted by my many other warm friends and associates among the staff), I have no hesitation in stating that the National Science Foundation Act has been an intelligent, satisfactory and forward-looking ing document. It has served the Foundation well and should continue to do so. In general it has provided the Foundation not only with authority to carry out programs clearly foreseen at the time of its issuance but also to initiate timely additional ones and especially to introduce these experimentally so that their character and growth may be more clearly determined from experience. In fact I find it hard to resist the temptation to remark that there is little about the Foundation's programs that more money will not fix.

In the National Science Board the Foundation has a notable asset and I can speak most warmly and enthusiastically about its helpful actions, advice, and guidance. It is in fact a unique body and one whose services I have always felt could well be authoritatively used on matters of national policy in science and education going beyond the Foundation's own programs—in Government-university relationships for example.

You have asked me to make specific suggestions or recommendations. I have some hesitation in doing so since the soundest recommendations are bound to come from those with active responsibility, namely, the Director, backed by the National Science Board. Besides, I do not wish to give the impression by my remarks that they are in any sense critical of Dr. Haworth's administration, for which I have nothing but praise.

I do have in mind certain points to raise as suggestions for consideration. They are as follows:

(1) Steps should be taken to materially increase the budget of the NSF in order that greater advantage may be taken of the proved assets in its programs. Specifically, the allocation for research support should be markedly increased in order that the Foundation may provide a greater proportion of Federal support in basic research to academic institutions.

The present figure, less than 30 percent I believe, is too low to enable the NSF to complement the basic research support by other agencies and insure that Federal support maintains a proper balance among the various sciences.

Furthermore, as I have explained, additional support in this category will bring about a more effective regional coverage, among large and small institutions, and in the educational advantages that such extension will provide.

Such a provision would also serve to strengthen the position of the NSF with respect to basic research policy within the Federal Government, a role for which it now has extensive experience and competence. This strengthening of its role should be of valuable assistance to the Office of Science and Technology in the latter's consideration of this and broader issues involving science.

As I have stated elsewhere,[1] in my opinion the proportion of Federal support of "mission-related" basic research is too high—about 80 percent. My reasons are as follows. One of the strengths of a country such as ours is the encouragement of free and independent inquiry. Completely free research extends the opportunities for new and valuable findings. Cultivation of the broadest possible base for research benefits interdisciplinary research programs; it prepares the scientific community for the broad knowledge and flexibility which are needed in a rapidly changing world. Finally, such a move would prevent overemphasis upon too few selected scientific fields, under programmatic and budgetary pressures.

[1] "The Changing Environment of Science"; Science, Jan. 1, 1965.

In this connection it should be remembered that the NSF is in the most effective position to encourage the intimate relationship that should exist between research and training at academic institutions.

As a practical administrative matter the NSF increase in workload to deal with an increased appropriation for this purpose would be relatively slight. The chief staff workload falls upon the scientist-administrators in the review and evaluation of proposals received. Thus, the workload is determined largely by the number of proposals received and not by the number of grants actually made.

(2) In the interest of improved communication and planning within each of the scientific disciplines and the potential utility of their findings the NSF should continue to develop the programs of its Office of Scientific Information Service, and also to exercise leadership in overall consideration of basic research subject matter areas. This may often involve or generate national research programs in which the Federal agencies may cooperate. Such cooperative undertakings should of course come under the cognizance of the Federal Council for Science and Technology.

(3) Increased use of the National Science Board as a distinguished and unique policymaking body in the area of research and education, with special reference to Government-university relationships in support of science.

(4) Continuation, at an increased level, of the program in support of education and training in science and engineering. This is a highly critical area for our future in science and technology. These programs have had marked success, and the NSF has established close and cordial relations with the scientific and educational community, by whom the programs have been enthusiastically acclaimed. By no means should this momentum be lost. It goes without saying that in this process there should be close cooperative relations with the Office of Education. The latter will be fully occupied with similar programs in fields other than science, and with overall improvement along general educational lines, especially in cooperation with the States.

(5) As on many occasions already, the NSF should be regarded as the logical colleague in the Federal Government of the National Academy of Sciences-National Research Council, the American Association for the Advancement of Science, and other scientific societies, in programs of mutual interest.

(6) One of the most serious matters in provision for basic research is to provide for (a) continuity of support and (b) contingency funds so as to take prompt action to followup a new and highly significant finding.

> (*a*) Lack of stability and continuity in research activity at academic institutions interferes critically with the effectiveness of their research programs, with the training of graduate students, and with the efficiency of their departmental and administrative operations.
>
> (*b*) A new research finding of high significance and promise calls for immediate research in verification and consolidation of its results and prompt extension of research activity to exploit the new discovery. At this stage there may open up an opportunity for applied research to investigate any practical benefits that may accrue.

During the 2-year interval required for the budgetary process, there is great likelihood that basic research findings may be made which demand this urgent followup. It then becomes highly urgent that funds be immediately available for this purpose, so as not to draw upon funds needed and morally committed to on-going programs of high quality and stability. I do not know the most expeditious way of providing such contingency funds but I can strongly vouch for their need and the strong backing of the scientific and academic community in so doing.

(7) The opportunities for cooperation in science programs with other nations is attractive, timely, and impressive. In so doing we may establish cordial and mutually beneficial relations in an atmosphere relatively free from troublesome political problems. For this we have a number of excellent precedents.

Besides the accomplishments of science and technology are going to become of greater and greater significance in the affairs of mankind. To make sound progress in such developments and to deal with them effectively will require the friendly collaboration of all. In such enterprises the NSF can play a leading Federal part, in cooperation with the State Department on the diplomatic and official side, and the National Academy of Sciences on the side of purely scientific relationships abroad, such as with the International Council of Scientific Unions and foreign academies of science.

In consideration of this and other problems in support of science and science education, one is inevitably led back to confront what is undoubtedly the most fundamental question of all; namely, consideration of our national goals.

Admittedly, progress in science is essential to the well-being of a nation in the world of today. In what sense is this true? For national defense, for health, for industrial and economic strength, for consumer benefits, improved standard of living and for cultural purposes? All of these surely, but is the goal only to achieve an adequate, acceptable standard in all of them? Unfortunately absolute standards in these categories cannot be accepted. We live in a competitive world; consequently standards have to be relative. Where or how are we going to stop in consumer benefits and improving the standard of living? What constitutes an adequate program in national defense or space exploration? Or an adequate science program? Among the community of nations and with our present responsibilities our answer must surely be that to compete successfully we must be in the forefront of research in science, in all fields. Why all fields? Simply because there is no predicting where the most significant progress may occur, and also because of the increasingly important interrelationships among the sciences—the so-called interdisciplinary approach. Now how should we deal with very expensive items? Should they be excluded solely because of their cost? In certain areas we cannot do that and maintain our position among the leaders in the field. If we adopt this negative position, then we are bound to experience periodic and rude awakenings, as we have already encountered on several occasions, with the ensuing overcostly crash programs and general consternation.

It goes without saying that such decisions are extremely difficult to make and that fiscal items of this magnitude must come into competition for funding with other programs lying outside or on the border of science. But in considering such items we should always bear in mind their feasibility. For example the record shows that we know how to build successful high energy particle accelerators which have lived up to the specifications of their designers. By the same token it may fairly be said by way of justification of man's trip to the moon that we know how to do it; we have far more assurance of succeeding in that than we have of preventing crime, of eliminating pollution or traffic accidents, or eliminating poverty, important as these problems are.

Finally, we must realize that world competition in science and technology is going to be a most serious matter. To meet this our best insurance is research, basic research to give the background and the leads for the future, and applied research to identify the feasibilities for development. In order to make optimum progress in science and at the same time provide for the requisite scientific and technical manpower we must concentrate attention upon supporting the colleges and universities that produce this trained manpower.

We must realize that science will continue to bring to light research and development programs of greater and greater import for mankind. These will be impressive but some will also be very expensive. If we fail to undertake them we jeopardize our position among the progressive nations of the world and our opportunities for leadership. If we do undertake them we shall then have the choice of financing and manning the effort alone, or enlisting the cooperation of other countries. In view of the global character of some of these ventures, their extreme cost, and possible social implications, we should give increasingly serious consideration to this latter alternative—taking the lead for collaboration among nations.

If we are to be able to do justice to the impressive potentialities of science and technology, one of our chief concerns must be a better public understanding of science and technology. Hopefully, in time, we shall be able to include science in the education of every child, but for the present it is important to try to give all citizens a clearer idea of the subject. Unless this general type of public understanding is developed, the country will not be prepared to deal intelligently or effectively with the major discoveries in science that are certain to occur.

Many of these will inevitably lead to issues involving technology that society will have to decide. Here the questions cannot be left to the scientists and engineers alone; their role is primarily to point out the scope and nature of a new field, its possibilities and limitations. We have already seen social questions of this sort arise. But it is certain that science will open up possibilities for development of an even more critical nature, in such sensitive fields as biology, for example. Imagine the social consequences of a discovery that would

prolong human life to double its present span, or one that would predetermine the sex or other characteristics of a child. We do not know at the moment what discoveries of such critical magnitude will emerge, but we can be confident that discoveries of this degree of importance will ultimately occur. When that time comes, it is clearly of the greatest importance that all educated citizens be able to take an intelligent position on these issues.

One cannot conclude a discussion of the far-reaching sweep of scientific progress and its consequences without stressing the involvement of international relations. An increasing number of scientific problems are and will be global in nature and can be intelligently and effectively administered only by international cooperation.

For all these reasons it is of the greatest importance to move in the direction of increasing international cooperation in science, and where feasible, in development and technology.

Along with the present breadth, complexity, and inherent power of science and technology we are finding ways of overcoming many of the environmental hazards that confront us and indeed to create for ourselves entirely new environments. However, we are also learning that such applications of science may introduce new problems and new hazards to overcome.

It is especially important to realize that we are now beginning to take large and unprecedented steps in the exploration of our surroundings—by research into outer space, into the ocean depths and into the interior of the earth. We are making notable progress in ecological studies of our immediate environment and the further development and conservation of natural resources. In the biosciences we are coming ever closer to a knowledge of the origin and development of life. And we are making significant progress among the behavioral and social sciences.

The potentialities of these undertakings are most impressive. They are of a character to warrant full attention and support by the Federal Government, both in national and international planning.

In the attainment of the science components of these goals, I firmly believe that the National Science Foundation occupies a unique position in our Government—one that should be maintained and enhanced.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I have several questions.

You indicated earlier that you attempted geographic distributions, or had done so in the past. Some comments were made in this regard by the present Director several days ago as to those projects which came toward the bottom of the pile and which are of nominally equal quality. I personally think this is a wise procedure. I also think that the comments made that the top proposals should be approved regardless of where the applicant happens to be is also equally wise. I am curious to know, however, what is the percentage of funds which can be adjusted to some extent on a geographical basis.

Dr. WATERMAN. I don't recall the figures which were of course only approximate. I believe the Foundation may be able to give them to you. The general type of curve shows a relatively small number of top quality proposals with the number increasing as one goes down in the quality scale, together with an increase in variety and source of proposals. Therefore, with a severely limited budget the coverage is limited; an increased budget increases the coverage and broadens the distribution.

Mr. VIVIAN. There is a system, I believe, utilized within NSF for rating. If I were to look at the last, say, 20 percent on the rating curve, I should find a different geographic distribution for those say, on the top 50 percent of the rating curve?

Dr. WATERMAN. Yes.

Mr. VIVIAN. I see Dr. Haworth in the audience. I would appreciate if I could get that information. I presume that is available.

Dr. HAWORTH. Not quite as specifically as you indicate. One can give a rough idea. The proposals aren't all assembled at the same time and rated with numerical ratings and so forth.

Mr. VIVIAN. I recognize that. I undoubtedly asked the question in a context which is hard to answer. I am sure there is some approximate context.

Dr. HAWORTH. We will do the best we can.

(The information follows:)

NATIONAL SCIENCE FOUNDATION,
OFFICE OF THE DIRECTOR,
Washington, D.C. August 16, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, House of Representatives, Washington, D.C.

DEAR MR. DADDARIO: During Dr. Waterman's testimony before your Subcommittee on Science Research and Development on June 30, 1965 (transcript, p. 290), I stated that the Foundation would furnish information requested by Representative Vivian on certain aspects of the geographical distribution of those proposals which were accepted for granting by the National Science Foundation. Specifically, Representative Vivian was interested in the geographical distribution of the top 50 percent and the lower 20 percent of the grants on the basis of quality rating.

A study has been completed of the regional distribution of the research grants made during fiscal year 1964 which included the upper 45 percent of the grants and the lower 19 percent of the grants, by number. These groups respectively accounted for approximately 52 and 13 percent of the funds. (Our rating system assigns projects into quality groups. The statistics were such that breaks between groups occurred at the points used.)

In attached table the region are listed in the order of decreasing NSF basic research support per Ph. D. I should also point out that the data determined were for only 1 year and that averages over several years might be somewhat different.

I shall be pleased to attempt to provide further information on this subject, if you desire.

Sincerely yours,

LELAND J. HAWORTH, *Director.*

Region	States	Regional fraction of total dollar amount contained in upper 45 percent of grants (by number)	Regional fraction of total dollar amount contained in lowest 19 percent (by number)	Percent of dollars in lowest 19 percent; percent of dollars in upper 45 percent
Pacific	Washington, Oregon, California, Hawaii, Alaska.	22.4	21.0	0.93
Mountain	Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico.	3.4	5.6	1.64
New England	Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.	18.4	10.5	.57
Middle Atlantic	New York, New Jersey, Pennsylvania.	21.1	17.0	.81
South Atlantic	Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida.	8.4	8.8	1.04
East North Central	Wisconsin, Michigan, Ohio, Indiana, Illinois.	18.4	21.4	1.16
West South Central	Arkansas, Oklahoma, Louisiana, Texas.	2.9	5.3	1.82
West North Central	North Dakota, South Dakota, Minnesota, Iowa, Nebraska, Kansas, Missouri.	4.6	6.7	1.45
East South Central	Kentucky, Tennessee, Alabama, Mississippi.	.4	3.7	9.25
Total		100.0	100.0	

Dr. WATERMAN. Of course, this is a statistical matter. One finds plenty of instances in small colleges where a grant is given to an individual because of the high quality of his proposal. I have talked to many small college presidents about this. Many feel that one of the best things that can happen to their institution is to have one of their faculty get a research grant.

Mr. VIVIAN. I also might comment that while sometimes the phrase "Midwest" is used around here, I am also aware that in other portions of the country which are labeled as being high on the scale of those receiving research grants very often some of the smaller institutions in those areas are perhaps as undernurtured as any other institution in the country. There is a macroscopic view to this problem as well as a microscopic view.

I would assume that I would find a distinct difference in the distribution between these two ranges on the scale?

Dr. WATERMAN. That is my impression as I recall it, yes. In fact, that is one of the reasons why the curves of distribution in different parts of the country came out as they did, roughly in proportion to the number of active research people, to the number of college graduates, even approximately to the population, and the fellowships show much the same distribution. Under these circumstances the smaller colleges are bound to receive far less research funds, wherever they may be.

Mr. VIVIAN. My impression is NSF is doing a better job than the other agencies in this regard, and my remarks are not meant to deter this.

I would like to comment briefly on the split between the mission agencies and NSF. From my observations in dealing with the agencies, the principal merit of having them conduct basic research opposed to NSF sponsorship is not potentially obvious. I am talking here specifically about basic research as opposed to applied research, for example, advanced mathematics rather than applied mathematics. The defense agencies may not sponsor as much mathematics research as NSF, yet they do carry on a moderate amount thereof. The only basic reason I can see why they should continue it is that there is a requirement that members of these agencies, the personnel working in the agencies, be able to speak with reasonable effectiveness and be able to be conversant with modern fields. Therefore, the amount of research I would presume they would need would be the amount required to effectively educate the employees of the agency. Some of this is going to be done outside the agency because the personnel are so busy with their own internal programs and their own contract award work that they cannot do this, but they can benefit from external activity which is brought in to them as part of their contract work and effectively explained to them. It is an excellent procedure. I think it is a wise procedure. However, I would tend to expect the amount of research they support is well in excess of this amount. I, therefore, go back to the question of how much do they support.

Earlier this month I had a series of statistics on how much research was carried on by the several agencies. NASA research encompassed several dozen launch vehicles costing hundreds of millions because it came under a label of research. Under the sponsorship of other agencies, such as the AEC, DOD, and so on, the word "research" had a

different interpretation. My impression is that it was quite intentional that it was differently interpreted, namely, so there would be the least argument possible on the subject. If a uniform standard were applied, I think we would find a drastic restriction of those statistics, and we would find a totally different interpretation placed on this thing.

I am a strong believer that research and development needs to be done, especially that defense development needs to be done, but I am also convinced that more in basic research should be done in NSF rather than in the defense agencies. I think the criterion should be the basic education of the employees in the agencies and not the conduct of basic research.

I suppose if I asked anyone in NSF to provide me data on this subject, NSF would find itself in an embarrassing position; so, I won't do it. Who should I ask?

Dr. WATERMAN. I would say ask the agencies themselves why they are doing basic research.

Mr. VIVIAN. I have already indicated that will be a question I will ask, but I am not in a position to say whether I will believe the answers or not. Is there any third party?

Dr. WATERMAN. Such a question, if this becomes acute, would be a matter for study by the Office of Science and Technology. That is where the authority lies for this sort of thing. The coordination on these matters would take place in the Federal Council for Science and Technology.

I know just what you mean because I was for 5 years with the Office of Naval Research, which serves the Navy. The reasons for other agencies conducting and supporting basic research are important. Take the Navy's case. If basic research should be done entirely by the Foundation rather than by the Navy, the Foundation for example would never devote as much study to underwater phenomena as the Navy needs. The Navy needs that, and it needs it directly.

In other cases one can't always point to direct use so clearly. It is the agency's job to determine this, and the responsibility of the Office of Science and Technology, and the Federal Council as well, to watch it. One cannot lay hard and fast boundaries and say that only certain fields can be done by the Navy, for example, because requirements and opportunities change as time goes on.

Take the field of ornithology, bird study—do you think the Navy should be excluded from research in ornithology? Well, in the South Sea Islands if you knew their cries and habits tropical birds might give you an idea of what the enemy were doing. So, isolated studies can be important, but they have to make sense.

I think a protection against what you are concerned about is by providing more funds proportionately for basic research to the National Science Foundation, and, therefore, forcing the other agencies perhaps to be more selective. That would avoid some of the dangers you speak about.

Mr. VIVIAN. What I am concerned about is as follows. As I recollect, the price tag allocated to basic research is approximately \$1.7 billion. A sizable portion of this is for rather expensive facilities, and I will call the rocket booster a facility for the moment, so perhaps the real amount is about \$1 billion. A great deal of this is contracted in amounts of from \$50,000 to \$250,000 at a time. I may not have the right

median, but I would expect the median of $200,000 is probably not far from the fact. That means if you were to evaluate all the proposals, you would be evaluating approximately 5,000 or 6,000 proposals. I cannot see how the Office of Science and Technology, Dr. Hornig's Office, could efficiently evaluate 5,000 or 6,000 proposals as to which agency each should belong. I think it is beyond the capacity of the Office. Therefore, I presume there are guidelines which exist as to what is NSF-related, DOD-related, and so forth. Are those guidelines written down? Does a contracting officer in, for example, the Office of Aerospace Research have a set of guidelines as to what he is not to fund in OAR and what he is to transfer to NSF?

Dr. WATERMAN. I think one would have to ask the individual agencies whether they have such guidelines internally. I don't know that there are any external instructions on this other than their mission and the Executive Order 10521 I mentioned earlier.

My former remarks were answering the first part of your question. Let me answer the second part; how does one establish a way to keep such an agency from getting too much research funds? One is by the total budget of the agency which is generally under pressure to stay limited, and the vital things to the agency are their actual operating programs, not basic research. So, in the course of time, basic research is one area that begins to be squeezed. This provides a corrective measure. In the case of a new agency like NASA this effect has not had time to take place; they have to go ahead with basic and applied research for their new developments. NASA represents an outstanding case in the difficulty of determining basic research costs. If one is sending up a satellite or a probe for basic research purposes, obviously the equipment in the vehicle should be assigned to basic research. But what about the operation of launching the vehicle, which is a heavy cost? What about development of the vehicle that is used to get it up? Should this be included in the cost? So, there is a real problem here to arrive at accurate and comparable research costs.

If I am not mistaken, the decision in these cases is not to put in the developmental costs of a vehicle that can be used for other purposes and which happens to be used for basic research, but a vehicle that is designed exclusively for basic research should have its cost chargeable to basic research.

As a partial solution I believe that sums like this should be placed in a different category than the support of basic research such as the regular programs of universities. If they are separated out and put by themselves, then they can be judged more accurately.

It is a troublesome question—what one can do about a very costly installation which is necessary to do certain basic research and does not represent the actual cost of doing it.

Mr. VIVIAN. I would like to ask Mr. Yeager to inquire into the guidelines used in these various agencies by the contract administrator, specifically, as to the letting of the contracts, which would be in their purview or not.

I would suppose as to these agencies, such as OAR, there would have been a fair number of times when a certain research activity which they would have liked to have funded under their budget has been squeezed out by the pressure on the total budget. They may

say: It is something we are in favor of, and we would like NSF to carry this under their aegis, if possible. Does this occur frequently?

Dr. WATERMAN. I am not up to date on this, but it has happened repeatedly in the past. ONR pioneered in basic low temperature physics and AEC picked it up as well. Later both agencies didn't feel they could justify it sufficiently, and they both asked NSF to take over.

Mr. VIVIAN. Does this characteristically happen?

Dr. WATERMAN. Oh, yes.

Mr. VIVIAN. It has not been impeded by any internal agency attitudes?

Dr. WATERMAN. It is hard to make a statement about that. Some agencies might occasionally want to hold onto some research perhaps longer than appropriate, but primarily this is a matter between the agency and its research office.

Dr. HAWORTH. As the growth of the budgets of the mission-oriented agencies, particularly, not so much NIH but others, has tended to level off, it has happened more in a little different sense than you are talking about. Not necessarily that OAR has said it is not appropriate for research in this field, but it doesn't have enough funds to support as many programs as, say, it has been carrying on, and in recent years the NSF has taken over several such programs in nuclear physics, for example. We are presently discussing with OAR the possibility of our taking over the operation of the Arecibo radio astronomy installation in Puerto Rico and various more of the nuclear physics and some of the materials programs and things of that sort.

Mr. VIVIAN. Certainly OAR should receive a great deal of credit for its work in radio astronomy in years past.

I would like to comment to all of my scientific cohorts of years past who feel that a single agency has control over all funds on a given subject, have made a tremendous mistake. I am equally adverse to these mission groups being cut out of the picture. I think the relative percentages should be adjusted in some reasonable way.

I have nothing further, Mr. Chairman.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. No questions.

Mr. DADDARIO. Dr. Waterman, since Reorganization Plan No. 2 transferred some of the NSF functions to OST in the field of evaluating scientific research programs undertaken by agencies in the Federal Government, the question arises whether OST and its staff in fact have that capability. Mr. Vivian has again raised that particular question. Would you care to comment?

Dr. WATERMAN. I should say that what this really did was to transfer the evaluation of agency programs to the OST. It still leaves to the Foundation the development of national policy with respect to science, in particular as a help to OST.

In any such evaluation the Office of Science and Technology in the first place has the help of the Federal Council for Science and Technology for mutual review of agency programs and the problems which they raise. This gives a concerted Federal view of what the agencies are doing. Then, it has the President's Science Ad-

visory Committee, which, of course, cannot regularly go into great detail but can consider critical problems and is extraordinarily expert in its insight into research quality, and the ways in which science at a given time is moving most significantly.

Evaluation in detail is, of course, a huge job. It cannot be done project by project. There are too many of them. I don't know what the total is now in the Federal Government, but it is well up in the tens of thousands. It must be done by categories, and within the categories, brought to the attention of expert panels. To begin with, the agencies should be sharply aware of their responsibility for their own review in the formation of their programs, their use of advisory committees and how well they exercise judgment in carrying out their programs. That is to say, at the start is the best place to begin this evaluation. Each agency should be held responsible for doing an excellent job there.

Then without actually reviewing the programs of the agencies one can judge the competence of the advisory process and the competence of the staff.

Personally, it seems to me we are embarking on a very sound procedure right now in the thorough review by the committee headed by Dr. Kistiakowsky, and by a panel of the President's Science Advisory Committee doing likewise in the overall picture. The program has reached a size and cost now which make this highly advisable.

However, we should not find it necessary or desirable to do this year after year. The effort is too great in time and money. In the meantime I should like to see increased use of the experienced science administrators in Government taking their share of this appraisal, first, by their responsibility to their own agency programs, and, second, by greater use of the cooperative techniques that I spoke about which the Foundation has used quite extensively; namely, by agency science administrators in the different disciplines keeping in close touch with their opposite numbers. In this way by closer association among them, better quality standards are achieved, and these administrators themselves are better able to ride herd on the quality and kind of research in their own agencies. Thus by internal community effort one can achieve a valuable kind of review and improvement. This can be made more formal if it seems desirable. I think it ought to go fairly well without formal organization. For example, the head of the research program in the Foundation in physics, chemistry, or psychology could have meetings with his opposite numbers in the other agencies, and they could determine pretty well as an interim measure the quality and distribution of Federal support in that field. I think this would be helpful, and it would obviate the necessity for frequent elaborate reviews like the present one. These intensive reviews ought to take place only at rare intervals so as not to make excessive demands upon the time of the ablest research men of the country. Such a procedure could greatly help the Office of Science and Technology. In this way the latter could decentralize its efforts to some extent and avoid having to acquire such a large staff.

Mr. Daddario. What you are suggesting, then, is periodic reviews but more formalized meetings of the responsible people?

Dr. WATERMAN. Yes; closer communication and cooperation at least, formality to the extent that is necessary, and to some extent perhaps delegation of this function by the OST.

Mr. DADDARIO. Whether that evaluating function is in the hands of the National Science Foundation or the OST, as it now is, it would not in any serious way affect the ability of NSF to formulate policy in this regard because the information would be equally available?

Dr. WATERMAN. Right.

Mr. DADDARIO. Dr. Waterman, I appreciate your testimony, and I hope we might have occasion to send some additional questions to you.[1]

Dr. WATERMAN. I would be very glad to answer them, Mr. Chairman.

Mr. DADDARIO. Mr. Yeager.

Mr. YEAGER. Dr. Waterman, would you make the same recommendation you made about keeping basic research spread among the various agencies in connection with the support of science education?

Dr. WATERMAN. No; not in the same way.

Mr. YEAGER. To some extent at the present time the various agencies have fellowships and training programs.

Dr. WATERMAN. I would be very careful about this. It seems to me an agency with a practical mission should in the first place deal only at the graduate level where research is the important thing and its plans should be carefully coordinated with NSF for science, and for other fields with the Office of Education. I also believe they should have the privilege, for example, of establishing special fellowships in an area of interest not adequately covered in general fellowship programs such as those of the NSF. In that sense it would correspond somewhat with the basic research policy. I don't think they should deal with undergraduate activities, nor with secondary and primary schools. I believe their educational support to academic institutions should be confined to cases where the institution could profitably use a laboratory or other unit devoted to special research in their field. This should be looked at with a great deal of care, however, and action taken only when fully endorsed by the institution as a policy matter. The extent to which special institutes or research centers need to be set up is another policy matter, and whether they need to be associated with a university or not. I believe the possibilities exist, but action should be taken only with a great deal of care and judgment.

Mr. YEAGER. Do you think this should be coordinated with NSF to some extent since the need will depend somewhat on the data NSF has collected?

Dr. WATERMAN. Yes; definitely.

Mr. YEAGER. You stated you felt that more use should be made of the National Science Board by other councils of the Government, did I understand you correctly, or did you mean in the Foundation structure?

Dr. WATERMAN. I meant that more use could well be made of the National Science Board as to national policy with respect to science and in educational institutions, not necessarily confined to the NSF structure. Possibly it could be useful to the Office of Science and Technology. The Board is a unique body. It has an extremely dis-

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

tinguished and able membership for purposes such as Government-university relationships. Now, I don't know in what connection this might be most useful. My first thought is that it could be very much so in Government-university relationships, in the support of research and education in science. But it is a body which is unusual in its competence and representation.

Mr. DADDARIO. Thank you, Dr. Waterman.

This committee will adjourn until 10 a.m. tomorrow at this same place.

(Whereupon, at 12:07 p.m., the meeting was adjourned to reconvene at 10 a.m., Thursday, July 1, 1965.)

NATIONAL SCIENCE FOUNDATION

THURSDAY, JULY 1, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10:20 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., the Honorable Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. This meeting will come to order. Our first witness today is Dr. Dael Wolfle, who is executive officer of the American Association for the Advancement of Science, the large national membership society that represents all fields of science. He received the bachelor of science and master of arts degrees from the University of Washington, in Seattle, and his doctor of philosophy degree from the Ohio State University in 1931.

Dr. Wolfle, we are happy to have you with us, and we look forward to hearing from you.

STATEMENT OF DR. DAEL WOLFLE, EXECUTIVE DIRECTOR, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Dr. Wolfle. Mr. Chairman and members of the committee, the National Science Foundation has become the standard source that is used by all of us who are interested in statistical information on the Nation's scientific and engineering manpower and on financial information concerning the research and development effort. An explanatory footnote crediting the National Science Foundation as the source is found in countless tables published in congressional committee reports, reports from other Government agencies, from industry, in the public press, and in scholarly papers and monographs dealing with research and development or scientific manpower. All of us who use such figures are indebted to the National Science Foundation, for the amount and detail of information available now are very much greater than could be found anywhere a dozen years ago.

But those of us who want and use such information are not satisfied. We would like to have more, we would like to have it in greater detail, and we would like to have it more promptly. There are several reasons for these feelings of dissatisfaction, some of which may be under the control of the National Science Foundation and some of which are not. I wish to mention four of these reasons.

51-204—65—vol. 1——12

First. The questions that we can ask outrun the information that is available. No matter how hard the National Science Foundation, the Bureau of the Census, the Office of Education, the Bureau of Labor Statistics, and the other agencies that provide statistical information work, we can always think up new questions that they have not anticipated. As a result of these pressures and their own initiative, NSF and the other agencies have greatly expanded their statistical reporting services. The annual series known as Federal Funds for Science, which is the standard reference source for information concerning Federal expenditures for research and development, started as a slim little publication of some 40 pages. Now it takes some five times as many pages of finer print. The occupational classifications used by the Bureau of the Census have become increasingly detailed. The U.S. Office of Education reports the numbers of academic degrees awarded in much finer detail than formerly.

The reports published by NSF and the other agencies are, therefore, increasingly complete, increasingly detailed, and increasingly useful. Yet it still remains true that we can think up new questions that are not answered by the published reports.

Second. The second reason is that neither NSF nor any of the other agencies can possibly ask for all of the information that someone may wish to have tabulated. Restraint is necessary. To collect data for the National Register of Scientific and Technical Personnel, the NSF sends a long questionnaire to a large number of scientists and engineers. The Office of Education sends questionnaires to every college and university in the United States. It takes time, and sometimes it costs money, to supply the requested information. The collection is always a burden on the original sources. Restraint is necessary, or those sources will simply balk and refuse to cooperate.

Third. Some of the questions that are of particular interest deal with future trends and projections. We would like to know how many degrees in engineering will be conferred in 1970, or what the demand will be for chemists next year. Trends can be projected and estimates can be made, but a number of assumptions are always involved in these processes, and some of the factors that will turn out to be important in influencing future trends cannot be accurately predicted, and others cannot be foreseen at all. In addition to these inherent limitations, it is also true that the methodology for projecting manpower trends, particularly on the demand side, is not well developed.

Fourth. The fourth reason for dissatisfaction with the information available results from the very nature of the situation. One of the reasons for dissatisfaction is delay. Publications on finances and on manpower usually report the situation as of 1, 2, 3, or more years ago. There are many opportunities for introducing delay into the system. When NSF mails the National Register questionnaires to American scientists and engineers, some of them are busy, some are off on field trips, some are in Washington for committee meetings, and so there are delays in returning the original questionnaires. When information is sought from universities, it frequently takes a considerable amount of time to compile and transcribe the requested figures. When information is sought from industry, it may be necessary to translate from the recordkeeping system used by a particular company to the system used in the questionnaire.

After the questionnaires are returned, a considerable amount of time is required for tabulating and editing the data, for checking discrepancies, in waiting for tabulating machine time, in waiting for review and approval, and in getting the reports printed. Some of these delays could be reduced, but they can never be eliminated.

Another aspect of the nature of the situation is the fact that statistics of interest are collected by a number of different agencies. Among the Government agencies, the chief ones are the National Science Foundation, the Bureau of the Census, the Bureau of Labor Statistics, and the Office of Education. In 1958 a special advisory panel to the National Science Foundation and the President's Committee on Scientists and Engineers prepared a report entitled "A Program for National Information on Scientific and Technical Personnel." That report, which is generally known as the Hauser Committee report, led to various governmental considerations which eventuated in naming the National Science Foundation as the focal agency for coordinating the scientific and specialized manpower statistics gathering and reporting activities of the several Government agencies. Designation of NSF as the focal agency was a useful step in improving matters, but "focal agency" is a status that has no teeth or police power. The Foundation can coordinate the activities of the other agencies only by persuasion and through voluntary agreement. This is perhaps all that should be attempted, but we should recognize that no one has really given high priority to the job of collecting, maintaining, and reporting statistical information concerning the Nation's scientific and technical manpower. The National Science Foundation has not, nor has the Bureau of the Budget, nor has Congress. Work must be done when and as personnel are available, and must be laid aside when jobs of higher priority arise. Let me cite one example.

In the Hauser Committee report of 1958, it was agreed that it would be highly desirable for the Bureau of the Census to make a special study of a sample of the persons identified in the 1960 census as having earned college degrees or as being engaged in scientific and technical occupations. It was generally agreed that such a study would be of widespread value, and planning for it started in 1959.

The basic census data were collected in 1960, but the Bureau of the Census then had to devote its time to the tremendous job of getting the major census information ready for publication. It was therefore not until 1962 that the Bureau of the Census, under a grant from the National Science Foundation, could start collecting the data for this important special study. The questionnaires were distributed and collected in 1962; tabulation plans were made in 1963; the tabulations were completed in 1964. The first analysis of these data should be available shortly. And perhaps by the end of 1965, but more likely some time in 1966, we will have a valuable source that we would have liked to have seen in 1961.

When one is dealing historically with such information, it is more important that the data be accurate than that they were published quickly. But one also wants to have data available that will be useful in shaping policy now, that will be of greater value in projecting the future, and that will help us to decide what actions we should be taking this year and next. For these purposes, greater promptness is necessary.

There are four recommendations I wish to make to decrease the delays and to increase the usefulness of the statistical program.

1. The first concerns priority. Gathering and publishing statistics is not the most important job the National Science Foundation has to do, but personally I believe it merits a higher priority than it has been receiving. On this point we must make a choice. If we agree that the statistical information is inadequate and becomes available too slowly, we know how to give this function a higher priority. If we do that, we can, as one example, ask the National Science Foundation and the Bureau of the Census to start soon to arrange for the collection of data in connection with the general census of 1970 that will allow prompt publication of a special analysis of scientific and technical personnel and of the Nation's college graduate population.

If, on the other hand, we do not believe that these data-gathering responsibilities merit any higher priority than they have been receiving, we ought to stop complaining about performance and delays.

2. The delay in handling manpower data could be reduced somewhat if data processing equipment of higher speed and capacity were available. As I pointed out earlier, some of the delay is unavoidable. Still, faster reporting would be possible with better equipment.

3. I recommend that NSF be asked to study the feasibility of collecting a different kind of manpower information, a kind that I will call "flow" information to distinguish it from the information on current status that is usually collected and reported. Most scientific manpower studies are like the decennial census in that the data collected deal with the status of the whole group at a particular time. Thus the periodic surveys of the National Register of Scientific and Technical Personnel answer such questions as: How many astronomers are there? How many chemists have doctor's degrees? How many biologists are employed in industry? These are the same kinds of questions that are answered by the decennial census.

The Bureau of the Census supplements this status information by conducting a large number of studies of small samples of the total population to secure current information on geographic mobility, occupational changes, and other important trends and changes.

Similarly, it would be possible to supplement the periodic studies of the National Register by sampling studies that would give current information on transfers from industrial to academic positions, and vice versa, from one region of the country to another, from one area of science, such as physics, to a neighboring area, such as electrical engineering, or from employment to retirement.

The Federal Government has a greater need than anyone else for up-to-date information of this kind. In considering new legislation or new programs in which science and engineering are involved, account is taken of the number of dollars required and of the facilities that are available or must be constructed. Account is also taken of the human resources required and available, but the evidence is usually much poorer than that available concerning costs and facilities.

Let me cite an example. A few years ago, the President's Science Advisory Committee saw a need for a larger number of persons with graduate training in engineering, mathematics, and the physical sciences. Congress agreed and provided a larger number of graduate fellowships, traineeships, and loans. Let us accept, therefore, as the

first element in a complex problem, the need to stimulate a large number of students to secure graduate training in engineering, mathematics, and physical sciences.

The second element concerns the faculty. It was widely believed that not enough of the new recipients of doctor's degrees in engineering, mathematics, and the physical sciences were entering college and university teaching and that too many experienced faculty members were deserting teaching for research or industry.

As a third element in the situation, there was some indication that, due to lack of laboratory facilities and for other reasons, the university teachers were not training as many graduate students as they might.

Obviously, these three elements are interrelated. If the faculty is insufficient, either the number or the quality of graduate students will suffer. If the faculty is not training as many graduate students as might reasonably be expected, better facilities and internal changes in the educational system could produce a larger number of new doctorates, even without an increase in faculty size.

These general relationships seem clear enough, but data on the quantitative relationships that would have been helpful in deciding how many additional fellowships and traineeships to provide were quite inadequate. So the decisions had to be made largely on the basis of assumptions rather than hard facts. This is often the case in dealing with manpower questions.

This particular situation inspired Richard Bolt to develop an interesting mathematical analysis of the feedback of new Ph. D.'s in the sciences into the educational system, a model in which he could state quantitatively some of the relationships involved. The model that Dr. Bolt and his colleagues developed (Science, May 14, 1965, pp. 918–928) brings some interesting new thinking into our consideration of scientific manpower trends and studies, but I call attention to the fact that the actual data that Dr. Bolt could use were 2 to 4 years old when the analysis was published. Up-to-date information of the kind that I am advocating would make such models distinctly useful in deciding on policies and programs concerning future needs, desirable levels of fellowship programs, the need for teachers, the planning of facilities, and similar matters.

4. My final recommendation is that it is time for a new kind of agency or partner in the field of scientific manpower studies. From 1950 to 1954, I directed such an agency. It was financed by the Rockefeller Foundation and worked under the sponsorship of the National Academy of Sciences, the American Council of Learned Societies, the Social Science Research Council, and the American Council on Education. The studies that we conducted dealt broadly with the whole set of problems of the identification, education, and utilization of talent in the United States, and in some ways constituted a pioneer exploration of the whole area of specialized manpower. When we finished, we went out of business. We discussed the possibility of seeking continuity, but decided that the time was not ripe. Now another study of a somewhat similar nature is being started under the auspices of the same four groups and with financial support from the Carnegie Corp. and the Russell Sage Foundation. It too is established on a temporary

basis, and presumably will go out of existence in 2 or 3 years when its report is completed.

I propose that it is now time for a permanent agency of this nature. There are some problems that cannot be well handled as part of regularly scheduled data gathering and publishing operations. The National Science Foundation is under too much pressure to maintain the schedules of its periodic reports, and it is called upon too frequently to provide special analyses and tabulations to congressional committees and other agencies of Government, to allow it to give adequate time and thought to some of the methodological studies that should be carried out, to the interpretation and meaning of trends, or to the synthesis and correlation of studies carried out by several agencies. As a single example of the kind of work that this proposed organization might undertake, there is need to improve the methods of projecting future manpower demands. There are some ideas as to how projections might be improved, but no one has had time to try them out.

It is unlikely that such studies will be carried out by the operating staff of NSF or any of the other agencies, but they would be appropriate for the kind of new agency I am proposing. I would suggest that this agency be a step or two removed from operational responsibility. One thinks of the Institute for Defense Analyses or the Rand Corp. as roughly analogous models, or of an agreement with the National Academy of Sciences as a possible mechanism. If such an organization is established on a continuing basis, it should have some Government support, but it would be eligible for and undoubtedly would also receive support from nongovernmental sources. It would be a strong ally to the statistical groups in the National Science Foundation, the Office of Education, the Bureau of the Census, and the Bureau of Labor Statistics. Working in cooperation with those agencies, it could conduct supporting research. It could integrate and interpret some of the data gathered by those agencies. It would sometimes serve in the useful role of external critic. It could work to improve methodology in the field.

Eleven years ago my colleagues and I decided that the time for such an organization had not yet arrived. Since then, NSF has developed a valuable series of statistical records about the Nation's scientific manpower; other agencies have extended their services: a number of special studies have been carried out by Government and private groups; and the interest in and need for fuller and more accurate information have all grown to the point that I now consider such a supplementary quasi-governmental institution most highly desirable.

In conclusion, I want to repeat the first point I made: we are much indebted to the NSF; the information that is now available is both greater in quantity and better in quality than any of us had before NSF started. Yet further improvements are attainable. If you believe that better and faster data handling are desirable, my first recommendation is that the statistical responsibilities of NSF be given higher priority. Give the National Science Foundation a push, and help them, as the focal agency in this area, to push the other agencies.

I would also recommend that serious attention be given to the problem of securing better data-handling equipment and to the development of a new kind of manpower study that would secure up-to-date information on the flow of scientific manpower from one kind of em-

ployment, scientific field, or set of characteristics to another, to supplement the kinds of information that have been available, and to provide more timely information to use in making policy and operational decisions.

Finally, the time has now come to establish on a semipermanent basis a new agency that will not have as its primary function the collection of data, but that will be chiefly engaged in interpretation, synthesis, criticism, and the improvement of methodology.

Mr. DADDARIO. Dr. Wolfle, you have recommended the establishment of a new agency. Would you discuss that in relation to the ability of NSF to perform this function within the original charter granted to it by the Congress?

I recognize that you have indicated the pressures under which the National Science Foundation now operates, which might inhibit it from performing this particular function. However, if it were to be given the proper funds and the opportunity to do this, would this not meet your requirements?

Dr. WOLFLE. It could well be established with the National Science Foundation. I think it should be differentiated sufficiently from the data-gathering and reporting activities so that it would be free to do this slightly different job.

Mr. DADDARIO. The reason I ask this is because your recommendation would put it on a quasi-governmental basis with the opportunity to have funding from the private foundations from time to time. Because there are problems in that regard, and since studies to date have indicated that this kind of a program would be helpful, the question that comes to my mind is that this is a function the Government should provide on a continuing basis. The funding should be regular and not intermittent, as it obviously has been to date, where after a study has concluded there is a vacuum for a number of years before there is another study. It seems this might be the course that would develop if we were to follow the suggestion for an organization on a quasi-governmental basis.

Dr. WOLFLE. In suggesting the Institute for Defense Analysis and Rand as possible models I did not have in mind the size of their budgets but the one step removed from operational responsibility that allows them to be thoughtful allies to the participants in the Department of Defense or the Air Force, with which they work most closely. It would be possible to establish this new function wholly within the National Science Foundation, and it might work just as effectively there. The suggestion I made was to provide the insulation from putting out day-by-day fires that you can get by removing it, but the function is more important than the agency.

Mr. DADDARIO. Yes, I would gather from your statement that the important thing that you have recommended is the accomplishment of this purpose and not necessarily how it is done. You are not criticizing the National Science Foundation for not doing this because you do recognize that it does have these other requirements. You are saying that if it be done, it should be separate and apart from its other statistical gathering duties and requirements; is that correct?

Dr. WOLFLE. Yes.

Mr. DADDARIO. In an editorial in the June 25 issue of Science you referred to the applications of science. I wonder if you might go into

that a bit and tell us how you see the National Science Foundation in that context.

Dr. WOLFLE. That editorial probed in several different directions. My own judgment on that point is that the applications of science are so heavily the responsibility of many of the other agencies, the National Institutes of Health, the Department of Defense, the Atomic Energy Commission, NASA, that better balance overall is likely to be maintained if NSF does not have to become an agency primarily interested in applications. If it can retain its emphasis and center of interest in science, the whole effort will be better served than if it, too, would have to move into applied interest.

Mr. DADDARIO. Your feeling then is that it should resist the idea of becoming involved in the applied fields but stay in the pure sciences and bolster up its activities in the field of education. Applications should be left to the other agencies involved in the applied and developmental fields. This would keep NSF probably constricted somewhat in its growth, but heading in the direction toward which it could do its best job in the scheme of things?

Dr. WOLFLE. This would be my judgment; yes. Now, this isn't to say that the applied activities are not important. They are perhaps in some respects more important than we have been recognizing. But in terms of the maintenance of balance and in terms of fostering the scientific base upon which the applications rest, I would not move it in the direction of an applied agency but would follow the course you have stated.

Mr. DADDARIO. I recognize that does not mean that you downgrade the transfer of knowledge into the applied areas.

Mr. Conable?

Mr. CONABLE. No questions.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. Yes, I have a question regarding manpower. I am fairly familiar with the problem of training persons from other fields to be involved in science to meet any sudden increase of effort. I am curious to know, however, what your experience has been with having persons transfer out of scientific and engineering careers into other careers. Do you have any statistics on how often this happens, and the results that occur, and so on?

Dr. WOLFLE. I cannot give accurate figures, but qualitatively, yes. In general, the more lengthy and advanced training a person receives, the less likely is it that he will transfer into some other field. Thus, there is a much smaller transfer out of medicine into other areas than there is from engineering. There is a smaller transfer by those people who have reached, say, the doctorate level than those who stopped at the master's or bachelor's level.

Secondly, there is the problem of whether or not an actual transfer has occurred. The number of people who gets bachelors degrees in the sciences is much larger than the number of people who ever go to work in positions that one would class as scientific fields. This is also true of history, economic, philosophy; that is, the scientific undergraduate training is in a sense a kind of general, useful education, but is not necessarily vocational.

I don't know whether I have gotten at what you wanted.

Mr. VIVIAN. My concern is as follows: The physicians, the medical doctors, are generally in short supply; at least I think they are. There may be some arguments about that by the A.M.A.

The physicists are in a supply determined almost totally by allocations in these buildings. I think if we were to drop the allocation for science by, say, 30 percent, there would be an enormous oversupply of physicists, since most are hired by the Government.

The question I am concerned with is the extent to which persons who are no longer employed on Government contract activity are absorbed into the surrounding economic activity of the Nation. Has there been any surplus of engineers and scientists at any time within the last few years which has been unabsorbable?

Dr. WOLFLE. There have been some reports of surpluses when major changes were announced in defense contracts; and surely, when there are substantial cutbacks, there are individual people who are on the market and have to hunt for new posts. In a particular case, which attracted quite widespread attention, my information is secondhand; but, from some of the engineering organizations that did investigate, the people of quality were very rapidly snapped up by other companies, and it was the more marginal ones who were having the greatest difficulty of reemployment and who were——

Mr. VIVIAN. It is my impression that, after this recycling occurs, those persons who are dropped off the rolls are employed, often many thousands of miles away from the particular company which had dropped employment. They have very little difficulty in moving to other parts of the economy. Would you say this is correct or not?

Dr. WOLFLE. In general this seems to be true, yes, in our experience at least of the last 20 years.

Mr. VIVIAN. So the fluctuations in the budget support probably do not cause any great impact upon the economic welfare of these people?

Dr. WOLFLE. The people we are talking about are intelligent, educated, and geographically mobile in general, and there is at the same time a large amount of flexibility in whatever we mean by demand or need, so that there is room to move into adjoining kinds of work or freedom to move to other parts of the country, so that one hasn't had to worry about unemployment.

Mr. VIVIAN. Thank you.

Mr. DADDARIO. Mr. Roush.

Mr. ROUSH. Doctor, I read your testimony last evening, and I had one question which came to mind as I read your statement. It concerns your second recommendation that the delay in handling manpower data could be reduced if data-processing equipment of higher speed and capacity were available. I assume you refer to the National Science Foundation. Is this correct?

Dr. WOLFLE. I believe that both the National Science Foundation and the Office of Education, which process large amounts of data, are now studying their own needs and what newer and better equipment would aid them.

Mr. ROUSH. Are you familiar with the equipment which the National Science Foundation has?

Dr. WOLFLE. Not in detail.

Mr. ROUSH. Isn't your recommendation directed to the data-processing equipment of the National Science Foundation?

Dr. WOLFLE. Yes.

Mr. ROUSH. The reason I ask is that when Dr. Hornig was testifying before the committee, I specifically asked him the question as to whether or not the National Science Foundation had the most modern equipment and tools necessary for the collection and dissemination of scientific information. His response was that they did have. Therefore, there is a conflict between the two opinions.

Dr. WOLFLE. It certainly sounds so. I may be misinformed. As I say, I am not familiar in detail with the equipment they have. I have discussed this question with some of the members of the NSF staff, and have from them the report that they are studying what they could do to have better equipment for their own needs.

Mr. ROUSH. If you should obtain information which would show a deficiency in this type of equipment, I am sure the committee would appreciate it if you would convey that information to us. We would also appreciate hearing any recommendations you may have as to specific types of equipment which the National Science Foundation might use to better its program.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Doctor, it is possible also, is it not, that if they have this equipment, they are not using it for the priorities that you would deem most desirable? If you are going to check into it, this is something we would be interested in knowing. NSF may have very good data-processing equipment, but have not the time nor the personnel to use it in the matter for which you are seeking information.

I would like to ask you this, although it is not directly related to your testimony. There has been testimony by Dr. Teller and others recently that we have put so much emphasis on basic scientific research that we are neglecting applied science, and that as a result we may have lost our leadership in the applied scientific field.

From your point of view, is this trend detectable? Are many of our best people so immersed in basic scientific research now that we are not making the best use of our technology? Is that a manpower problem?

Dr. WOLFLE. I am not sure it is a manpower problem as much as a problem of interest and motivation. Basic science has certainly been receiving both financial and moral support to such an extent that it has become a more glamorous field than it used to be. There is, however, a great deal of work going on in applied areas. I think that the complaint that Dr. Teller and others have made might better be stated in terms of balance or application to civilian needs rather than an overall disregard of applied research and development.

We have been concentrating most of the applied activities on specific fields, and various commentators note gaps and discrepancies to which they would like to have greater attention given, chiefly in the nondefense, nonspace applications.

Mr. CONABLE. Does the National Science Foundation make a significant contribution to this trend toward basic research?

Dr. WOLFLE. Well, to the extent that the National Science Foundation has become large enough to be a significant contributor, which it now is, to the support of basic research, yes, it may. But the National Science Foundation money for basic research is still a relatively small fraction of the total amount that is going into this area, and it is still

true that although most, roughly two-thirds, of the total research and development funds come from the Federal Government, industry itself is putting several hundred million dollars a year into basic and applied research.

Mr. DADDARIO. Just following up on that point, however, the fact that the National Science Foundation contributes to this raising of the status of basic research is something which is good, and certainly we ought not to depress it. The hope, however, is that we can stimulate better ways to transfer the knowledge to everyday uses.

Dr. WOLFLE. Yes. We are all better off because of what the National Science Foundation has done to stimulate basic research, even if that has drawn some people away from applied interests.

Mr. DADDARIO. We are doing a good job in the transfer of knowledge, but we could do a much better one than we are.

Mr. Yeager, do you have a question?

Mr. YEAGER. Yes, Mr. Chairman.

Dr. Wolfle, on page 4 of your statement you say that we should recognize that—

> no one has really given high priority to the job of collecting, maintaining, and reporting statistical information concerning the Nation's scientific and technical manpower. The National Science Foundation has not, nor has the Bureau of the Budget, nor has Congress.

Do you think it would be helpful to amend the organic act of the Foundation to give greater emphasis to this function? I am particularly referring, as a possibility, to language something similar to that which was used in an Executive order dealing with the administration of scientific research in 1954. This enjoins the Foundation:

> To continue to make comprehensive studies and recommendations regarding the Nation's scientific research effort and to treat sources for scientific activities, including facilities and scientific personnel and its foreseeable scientific needs, with particular attention to the extent of the Federal Government's activities on the training of scientific personnel.

I am not suggesting this particular language, but something of this nature. Do you believe that it would help to have Congress give a further directive to the Foundation in this regard?

Dr. WOLFLE. Not unless you go beyond that. I doubt if just changing the wording would aid greatly. The organic act now specifies that the Foundation shall maintain a register and that it shall serve as a clearinghouse for information about the Nation's scientific and engineering personnel. It has been doing these jobs. It is in a sense a service function rather than a primary aim of the Foundation. It serves as a national source. It serves as a governmental source, and it serves as a basis for its own internal policy planning.

I would like to see it given a higher level of attention, a higher priority, and I may be wrong in thinking that a modification of the act would be insufficient.

The conclusions to which you come in the report you prepare here and the way in which the budget of the National Science Foundation is handled would be, I think, effective means of increasing priority. The total amount of money spent by the National Science Foundation in this area is, if one includes all of the policy studies, the nonstatistical as well as the statistical, of the order of 1½ percent of its current

budget, which seems to me to be a nonexorbitant level of expenditure to maintain a continuing body of information about the financial aspects, the manpower aspects, and the trends, for its own affairs and for all of the other governmental interests in manpower.

I think they could effectively use more money, and if I could take my choice, I would take more money rather than a change in the wording.

Mr. YEAGER. The Foundation could now allocate a greater percentage of its funds to this area, perhaps at the expense of something else?

Dr. WOLFLE. Yes.

Mr. YEAGER. Would you estimate that, say, 2, 3, or 4 percent would be a fair figure to get some of the things done that you have mentioned?

Dr. WOLFLE. Yes.

Mr. YEAGER. Thank you, Mr. Chairman.

Mr. DADDARIO. Dr. Wolfle, I refer again to your editorial on the 25th of June. You mention another possible change being that the Foundation should be given broader responsibility in the field of higher education. In your article you commend, and in a sense compliment, the agencies for working closely together in this regard. Then you say, and I would like to quote the last sentence of that paragraph:

> The next step could be a union that would frighten some of the interested parties and appear to others to be a new frontier of intellectual leadership undreamed of when the National Science Foundation was planned or established.

What type of union do you have in mind?

Dr. WOLFLE. It is, I believe, clear that the Federal Government will continue to have a larger role in educational matters over the Nation as a whole than it has had in the past. The whole series of legislative decisions of the past decade or so have extended the Federal interest both in amount and also in terms of the areas of interest or responsibility.

Somehow or other the responsibility has to be divided; it can't all be lumped under a single agency. We now have a National Science Foundation which deals at the advanced graduate, the college and, to a smaller extent, the precollege levels. We have an Office of Education that deals with nonscientific activities, but overlaps both into science in some of its fellowship programs and extends from the very elementary up through the highest levels. We probably will have Federal support for the humanities in the Humanities and Arts Foundation that now looks like a likely possibilty. It is possible to divide these several functions by field of interest or discipline; that is, the humanities on the one hand, the sciences on the other hand, other aspects somewhere else. It is possible also to make divisions in a horizontal sense as between levels of education.

What I was striking at there was the possibility of a more centralized interest in scholarship, in education at the higher levels as one means of dividing this responsibility.

Now anyone whose particular interest is in a given area would, I think—or some people whose particular interests are in a given area, would object to such an amalgamation. Some scientists wouldn't want to have their agency diluted by also being responsible for humanities,

or arts, or the social sciences, and some humanists may not like to play second fiddle to these other areas, and the Office of Education might be reluctant to give up some of its responsibilities.

But, as one trend to be developed over a span of years, I think we ought to consider the possibility of an office, an agency, or some title at relatively high level, that would have as its focus the maintenance of scholarship and education and research in the broad sense without too much worry whether the particular field be called history or botany or political science or physics or art.

This is a controversial subject, but it is one of the possible directions.

Mr. DADDARIO. It is a very interesting idea. I think it is one of the things that the Congress has to be constantly informed about because it is a matter of controversy in a sense. We have had occasion to talk to educators from time to time, and at the moment it would seem that the consensus in this area would indicate that the growing responsibility in each of these agencies is a good thing. However, an amalgamation of them could in a sense eliminate the competitive ideas which generate from each of the agencies. This is the controversy, I imagine, to which you refer.

Dr. Wolfle, I am grateful for your coming here and appreciate, too, the advice you have given us today. You have been an excellent and exciting witness, and the committee is grateful to you.

Our next witness is Dr. Chalmers W. Sherwin, Deputy Director of the Defense Research and Engineering (Research and Technology) for the Department of Defense. Dr. Sherwin is replacing Dr. Harold Brown as our witness today. Although we regret that Dr. Brown could not appear, we wish to have you know, Dr. Sherwin, that we are pleased you are here. Please give Dr. Brown our best, and thank him for having made arrangements for you to come. We know of the work you have done in DOD and we are aware of some of the testimony you have provided from time to time before other committees of the Congress. We are looking forward to your statement.

STATEMENT OF DR. CHALMERS W. SHERWIN, DEPUTY DIRECTOR, DEFENSE RESEARCH AND ENGINEERING (RESEARCH AND TECHNOLOGY), DEPARTMENT OF DEFENSE

Dr. SHERWIN. Thank you, Mr. Chairman. I appreciate the chance to be here. I will read Dr. Brown's prepared presentation, and then I will be glad to answer any questions that I feel I can answer.

I am pleased to be able to meet with you today and discuss the interaction between the Department of Defense and the National Science Foundation. These relationships are far too numerous to examine in their individual details. Therefore, I will attempt to explain them in general terms, and discuss their rationale.

Dr. Hornig has already described the top-level program and policy structure which has been rapidly developing in the executive branch during the past few years. Of course, these supply one kind of connection between NSF and DOD of which you are fully aware. I will say little more concerning these bodies other than that we in the Department of Defense believe them to serve a most useful purpose, as they regularly bring together those in Government research and de-

velopment at the policy level. Since it is also at this level of Government that major plans in research and development are considered, the mutual interaction in the Federal Council is leading to a much better understanding of the whole Government involvement in any large field of scientific activity.

The next set of relationships I will mention is that of direct interagency planning of activities between the Department of Defense and the National Science Foundation in major programs. A good example of this lies in the Antarctic research program in which our Department provides a major share of the logistics in meeting overall requirements of a national plan assembled under the direction of the National Science Foundation. In this large effort, Defense Department scientists also participate along with scientists of other Government agencies and the private sectors of our Nation. Our work thus becomes part of the overall coordinated effort under the NSF national office.

A very similar relationship exists in another program in which the National Science Foundation plays a central role—the International Year of the Quiet Sun. Since we have a number of interests concerned with meteorology, solar activity, ionospheric physics, geomagnetism, and aeronomy, we have quite a few of our scientific projects dovetailed into our total national effort in this program. Through these NSF coordinated program activities, we feel we have gained considerably in our ability to exchange data on some of the most peculiar and complex phenomena which we are studying. Scientific progress on global basis has been greatly aided by such massive ventures. In this field individual investigations have been plagued for decades by the puzzle of their tiny, inadequate supply of data, which was really much like one tiny piece of a giant jigsaw puzzle. Another large program in which we act under the coordination of NSF is the International Indian Ocean Expedition in which we are engaged in considerable oceanographic research.

Another set of relationships is developing between our agencies aimed at improving the coordination of our activities and mutual interests in small projects. Each of the military department units which are the major supporters within the Department of Defense of small projects (ONR, ARO, AFOSR), the research offices of the three military services, exchange status reports on their activity on small project proposals with each other and with the National Science Foundation, the National Aeronautics and Space Administration, and the Agency for International Development.

These status reports frequently lead to other more direct forms of coordination. It is not at all unusual for a program manager in the Department of Defense to refer a meritorious research proposal in which we see no particular relevance to the National Science Foundation for possible favorable action. We have never been in the position where we could afford to sponsor all research that might be scientifically interesting. In order to be constructive in assisting the growing numbers of talented scientists whose work does not fit our broad program objectives, we feel we now need to improve our referral system.

The present scheme is imperfect in that no one agency can ever be certain that they have made the best choice of the most relevant research

to their mission. Neither can they be certain that they have referred proposals to all of the agencies which might have an interest. In addition, there is an interesting overall statistic which is missing—the fraction of acceptable or desirable research proposals which never were accepted and sponsored. I feel certain that this latter information would be helpful to the NSF, to Dr. Hornig, and to the Congress.

A different kind of joint arrangement also exists, involving the mutual support of specific projects by the Department of Defense and the National Science Foundation. One of these is Stratoscope II, a high altitude balloon program in astronomy which involves both very basic research and the development of a high altitude, large payload balloon capability. This program is one shared between NSF, DOD and NASA. A second example is a joint radio-astronomy project at California Institute of Technology in which both the DOD and NSF have had strong interest.

These are the existing kinds of interaction between NSF and DOD. I believe there are some new mechanisms that will develop which will assist all Federal agencies to act more as a coordinated unit. One of these is certainly in the exchange of information on the detailed composition of our various research programs. We have two efforts now going which may serve as prototypes of better systems of exchanging this type of data. The first one relates to an agreement with NASA to exchange data in a common digital language on work programs in progress in the form of what is called a research and technology résumé. By this means we are already transferring data on all Department of Defense basic research projects into the data bank of the Science Information Exchange. More detailed data on all defense projects will be maintained in a central file within the Department of Defense. Perhaps this arrangement could profitably be adopted elsewhere in the Government.

A prototype experiment on data of this type has been carried out during the last 6 months in collaboration with NASA. This experiment is called Project ILSE (Interagency Life Sciences Supporting Space Research and Technology Exchange). It is aimed at using a computer file to produce an indexed list of life sciences projects so that effective coordination and balancing of programs can be attained. Although the experiment is not yet complete, we have found that we can get the necessary order in the information so that a group of specialist panels may now examine all of the projects in which they are each expert. The research and technology résumé system will permit this detailed coordination to be extended to all technical fields.

Mr. DADDARIO. Thank you, Dr. Sherwin.

Mr. Roush.

Mr. ROUSH. No questions.

Mr. DADDARIO. Mr. Waggonner.

Mr. WAGGONNER. We were discussing here this matter of coordination. Would the Department of Defense be willing to have some other agency in the Government be the coordinating agency, and subject itself to its decisions with regard to this research?

Dr. SHERWIN. At what level or to what size of project do you think this question applies?

Mr. WAGGONNER. At all.

Dr. SHERWIN. All projects. Let me state my own strong convictions in this regard, that the research programs and scientific and technology programs are a vital matter for all mission-oriented agencies, and their selection is generally strongly biased by their mission orientation, a fact which can be observed by the pattern of support which you will observe of the mission-oriented agencies with respect to the different fields and even in fields with respect to the various technical areas. They, therefore, will have a strong interest in supporting one area over another. If they had to get approval from a central agency for every program they supported, it would I think be a very cumbersome decision procedure.

The solution which I think would be more practical and is the one which we feel can be attained is to provide efficiently and easily by means of a digital reporting system an accurate description of everything that is going on. Under those conditions most adjustments of the modest scale programs—by modest I mean the smaller ones, below, say, a hundred thousand dollars a year size packages—can be readily made by interagency agreements without having literal authority or prior approval requirement by a superagency organization.

On the big programs, the large ones, the ones that involve, say, the very large accelerators, something like this, clearly the Government must provide some way or other some sort of centralization about who supports which project.

Mr. WAGGONNER. Is the new mechanism to which you referred a few moments earlier the one that you believe would work in this coordinating effort?

Dr. SHERWIN. Yes. If you look at the activities that go on in the various agencies, there are just thousands, probably at least 50,000, maybe a hundred thousand specific projects, research activities in basic research and applied research and technology being supported now by the Federal Government. Most of these have a close relationship only with a few others in the same field. A fast interchange of information of on-going work would permit people to relate these many things together efficiently. While the work is still in progress, permitting, therefore, mutual adjustments long before the work is completed.

Let me give you an example. I have mentioned ILSE, the program of interchange between NASA and DOD on life sciences. The last cycle of this coordination which went on last winter had in it nearly 4,000 what we call work units. The work unit is the natural unit into which packages of research are divided for local administration. It corresponds on the average to approximately one professional man-year of effort. It varies; it sometimes can be 10 or sometimes less, but on the average maybe 1 or 2.

In the case of the life sciences program there were 4,000, a little over one-half in defense and somewhat less than half in NASA. Out of these 4,000 work units describing ongoing work which were printed out and correlated on the computer, only six needed what you might call serious effort at coordination by the central committees. They were identified as having questionable relationship. I haven't heard what happened on those six. The thing that amazed me was that there was such a small number that were questioned by the joint

committees. There were 27 committees that looked at the entire program.

(The following additional information has been submitted by Dr. Sherwin:)

A detailed examination was made of the six pairs of apparently duplicatory project. Two pairs were found to be in unwarranted duplication, and one member of each was terminated. One pair was found to represent two different approaches to the same important and difficult problem and was justified. Three pairs were found to be nonduplicatory.

Dr. SHERWIN. I believe it was small because this ILSE program had been running for 3 years, and when they started to make up their fiscal year 1965 program 1 year ago they had a complete print-out of the entire program of both agencies in front of them for fiscal year 1964. As a result, each group had been in contact with every group that was working in its field. They had already had a series of meetings on a working level, and they had formulated a program such that very few things needed to come up for coordination by a central decision-making group. In the case of NASA and DOD we have a joint agency whose primary responsibility is to resolve these differences on a common basis. (The Aeronautics and Astronautics Coordinating Board.)

Mr. WAGGONNER. Is DOD expending any moneys to aid science education?

Dr. SHERWIN. Not directly. We support about $130 million which goes into universities in research programs related to the educational process. These are not the big contract centers but the research programs that are on the campus with the students, and in almost all of these graduate education in research is supported. That is essentially the degree to which we are involved.

Mr. WAGGONNER. Are you giving any money for fellowship grants to individuals?

Dr. SHERWIN. Not to my knowledge.

Mr. WAGGONNER. That is all, Mr. Chairman.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. For the past several years you have been interested in the project which might be known as "Where Do Good Ideas Start?"; that is, from where do key advances originate which come to the Defense Department as major system changes. Are there any conclusions about this project which you would like to mention at this time?

Dr. SHERWIN. Yes; I would like to make a couple of comments on it. It has been of great interest on my part for 2 years now to ask the question, Where did the payoff actually come to the Defense Department from our investment in research and technology? Has it been substantial? Is there any evidence that different ways of investing this money over the past 20 years have paid off more to Defense than others?

We have finally started on a serious effort. A pilot study was done last summer with a group of people in my office and from the military services under the leadership of one of the members of my staff, Dr. Lawton Hartman. Also we have a contract study with a contractor which has just now been completed. Both studies seek to identify the key advances in research and technology which in fact have turned out to be useful or vital to defense systems. We track the key events

down and find out how they got born, how they got generated, how they got supported, and examine the management environment in which they emerged. We entered into this with the expectation that we would see a pattern, and clearly there is a pattern. One of the most remarkable things which I didn't expect this because I am biased the other way, is that most of the key advances which turned out to be useful were closely associated with people that actually had systems equipment to design and build. I had expected that most key advances would come from people who were sitting around with a lot of equipment, in a relaxed atmosphere, thinking about what people ought to want. Also, we found that almost all of the key advances were initially financed by locally controlled resources. I suspected this would be the case since I had personal knowledge of a number of such events. Thus, practically nothing that is really hot is ever "pushed down from the top," it is rather almost invariably recognized by local people faced with a real problem, initiated by them without the benefit of any paper work and financed by hook or crook (if necessary) by some sort of locally controlled resources.

Mr. VIVIAN. What do you mean by locally controlled resources?

Dr. SHERWIN. It is company money, or is bootlegged money on the part of a laboratory, or it is money which is given under general direction which the local management can legally allocate without prior approval up the line. In other words, it is really locally controlled, and we found that practically all of the advances were initially financed under those conditions. It gives flexibility to the local management.

Much of our current contractual support is not that way. In many instances it is pretty constrained. But these inventions were not supported initially that way. They may have received specific support later when it got expensive.

Mr. VIVIAN. Do you think they received local support because it was tough to get higher support, or because it was a very attractive proposition that no one wanted to disclose?

Dr. SHERWIN. I think it was because of the ponderous delay in seeking higher support. In one case they did make an application and a year later they did get support.

I might say we are just launching a new effort to make a very careful study of this on a larger scale. The Defense Department has made the biggest investment in research and applied research of any organization in the world, certainly in the United States. We have invested about $10 billion in research and technology since 1946. We have an inventory of weapons that is worth the order of $100 billion.

Now, in the weapons that exist today there is buried an enormous number of technological advances most of which we have paid for directly or indirectly in the last 20 years. We want to find out what those key advances are and to what degree the improved performance of the weapons is due to them. We then expect to compare this net improvement in our weapons systems for the defense of the country with the actual investment that we put in—about $10 billion. I expect a very large payoff has occurred. Practically no weapon system is ever undertaken that does not promise to have at least double the cost effectiveness of its predecessor, if such existed. Most of them are considerably higher than this. Take a ballistic missile, for example,

if you increase its accuracy by two without increasing its cost it is four times as cost effective against hard targets. This very easily happens by a very modest change in guidance accuracy.

If we designed our systems today with the science technology of 1950, I suspect that, rich as we are, we could not afford them. I believe that if we make our study carefully, we will find that our investment in research and technology has been the best investment for defense that the country has ever made. If it can be calculated, I think the payoff will turn out to be absolutely enormous. We hope to get very solid data on this within the year.

Mr. VIVIAN. You have indicated that these came out of what you call mission objectives, in other words, certain goals. Is this somewhat in contradistinction, for example, to some of the endeavors of NSF which are general support endeavors? In addition, you indicated that these were under what you mentioned as free money, and I do not mean in the context of being inexpensive, but money that you were able to move about in areas that were not necessarily agreed to in the beginning. Has this led to any policy changes in contracting on the part of DOD, or do you anticipate that it will?

Dr. SHERWIN. Mission objectives are clearly vital in directing the effort in technology. I think you have to get the technical people exposed to the problem in a real way, and in addition you have to provide them with flexibly controlled funds so they can work on problems without waiting. Also, they must have a solid base of scientific knowledge which they can apply to the problem. Thus there are three things that are all necessary to produce utilized technology.

We feel that our contracting policy for our early development and our applied research functions could be profitably changed in the light of the results of these studies. However, we would like to wait a year and collect and study more than the 100-odd key events so far identified. We need a much larger number, probably a thousand or so, covering a bigger fraction of the weapons inventory, before making any serious effort to shift the policy. For 20 years the policy has been what I call a seat-of-the-pants policy—people simply generate personal opinions on how one ought to administer and how one ought to allocate resources. The trouble with the scientific community is that they are only really interested in how to spend the next billion dollars, not in what happened to the last billion. They just aren't interested in lessons from the past.

But it is terribly important today. I think that looking backward into the past and seeing what has really happened is absolutely necessary, and that the Defense Department is a perfect place to do it. We have the biggest, longest, and most varied history of investment, and we have a measurable output. Even though I believe the payoff has been very great, I think we can learn a great deal about how to use our resources better.

Mr. VIVIAN. You would think that some of the ideas may well apply to NASA; I am not saying they should, but they might.

Dr. SHERWIN. I am sure they would. It will be a long time before they will have the data base for such studies that we already possess.

Mr. VIVIAN. Would they apply to research on water pollution and desalinization?

Dr. SHERWIN. I think there would be general application to any goal-oriented activity which uses science and technology. The substantial and long history of investment by the Defense Department is important because it takes 20 or more years of history to perceive the full consequences. It takes 5 to 10 years for even applied research to come out at the end of the pipe, it takes 10 to 20 years or more for basic research to come out at the end of the pipe.

Incidentally, the payoff time is another thing we carefully observe; that is, when were the inventions made with respect to their applications? We have already picked up a number of key research events, as contrasted to applied research events, which are vital to national defense which have occurred in the interval since 1946.

Mr. VIVIAN. Do the provisions which exist in many defense contracts by which a certain percentage is left to the contractor for his own research efforts in any way in conflict with the work you are now undertaking?

Dr. SHERWIN. This principle is called the armed services procurement regulation allowance for independent contractor research. This has been going on for many years, and, judging by the output of useful results, is a good thing. Many of the contributions we identified came out of this fund.

Mr. VIVIAN. Can you identify them directly for the record?

Dr. SHERWIN. Yes. People usually remember what kind of company money was used. Some came from profits, and some came from the funds just mentioned. A fair amount came from people bootlegging funds not specifically allocated to such functions because they believed in an idea.

Mr. DADDARIO. What percentage of the contract do you allow an industry to use for this independently motivated research?

Dr. SHERWIN. It varies with industry and the organization, of course, and somewhat with history. I believe the numbers run around 1 percent or maybe one and a half, something like this, under the conditions where it is allowable against production sales. It is a fair amount of money.

Mr. DADDARIO. I imagine on occasion it runs higher than one and a half percent. We would appreciate it if you would get that for us. While you are getting that information, I think it might be helpful if you could give us the lowest and the highest percentages involved.

Dr. SHERWIN. Right; we will be glad to give you some examples.

(The information requested is as follows:)

Analysis—Independent Contractor Research (covered by advance agreement)

		Fiscal year 1963
Average allowance (in a percent of total sales)	percent	0.91
Lowest allowance (to any contractor)	do	.4
Highest allowance (to any contractor)	do	4.5
Total cost of contractor independent research and development program (as proposed by contractors)	million	$381.6
Total amount of proposed cost allocable to Government (determined by negotiation)	million	[1] $194.2
Contractor total sales (for this contractor group)	do	$21,315.0

[1] Most of this $194 million was applied research and exploratory development; only 10 percent or less was estimated to be basic research as defined by National Science Foundation.

Mr. VIVIAN. I will come back to that in just a moment. First, I would like to point out that the DOD procurement is on the order of $50 billion. I realize that manpower is a factor; however, $50 billion multiplied by 1 percent, for example, would be a half billion. That would be a significant fraction of the $1.7 billion estimated for basic research. In other words, the numbers under this program are not small.

Mr. WAGGONNER. That is not possible because $15 billion is in salaries.

Mr. VIVIAN. I am saying I have been very cautious.

Dr. SHERWIN. Our procurement is closer to $20 billion per year, and of the actual equipment to which these regulations apply it may be less than that. (In 1963, as the preceeding table shows, this amount was $21.3 billion.)

Mr. VIVIAN. This would drop it down to about $150 million.

Dr. SHERWIN. Still it is a rather substantial amount of money. I might add it is used for other things than research. It is used for proposal preparation and other necessary internal costs of doing business; so, it all doesn't get into research. Even then it mostly gets into applied research because this is where they get the shortest term and the highest probability of payoff.

Mr. VIVIAN. Perhaps the amount I mentioned was high.

If there are no objections, I have several other questions.

Mr. DADDARIO. You may continue. You are doing fine.

Mr. VIVIAN. You indicated some comments on the subject of interagency transfers on page 3. You comment, "It is not unusual for a program manager in DOD to refer a meritorious proposal to NSF." Would you have any idea what percentage of proposals this would apply to?

Dr. SHERWIN. No; I don't. We could find out if you are interested.

Mr. VIVIAN. Five percent, 25 percent?

Dr. SHERWIN. I would guess it is closer to 20 than 5, but I could inquire and get some estimates. It is not something that we keep systematic records on.

At present and for several years in the past there has been complete exchange of information concerning research proposals on a monthly written basis among the following Federal agencies: DOD, AEC, NSF, NIH, AID, NASA, ARPA. We consider this coordination to be very effective. We further expect centralized collation of all research proposal information to be accomplished in the near future, as mentioned in my prepared statement, through the Science Information Exchange.

Mr. VIVIAN. Why would you refer the proposals to NSF? Would it be because of relevance of the work or funds involved?

Dr. SHERWIN. It might be both. In the DOD agencies the relevance of the program to the general interest of the Defense Department is an important weighting factor. If you notice the ways we are supporting research, about 70 percent of all the engineering science in the universities is supported by the Defense Department. This is not an accident. The reason is simply that we have a strong interest in the engineering sciences. We are strong in chemistry and solid state and optical physics; we are are low on the biological sciences, where

the National Institutes of Health are high. So, over a period of time we have gradually focused our efforts on those programs which are most relevant to the Defense Department. Our budgets tend to get big in electronics. When we get a project in in some special area of chemistry, for example, and we can't touch it because of our budget limitations, we refer it to the NSF or elsewhere.

Mr. VIVIAN. Are there established guidelines printed and promulgated to guide your contract administrators and unit heads in what they should refer to other agencies under certain conditions?

Dr. SHERWIN. I believe not.

Mr. VIVIAN. Would you construe such guidelines as being undesirable or not?

Dr. SHERWIN. I think they are probably not necessary. Each of the three agencies has a very well thought through general plan of their research program for the next few years, and they compare the proposals coming in with where they are trying to go, and then they pick the things they feel are most relevant or most exciting or the best combination, and they refer the others to the other agencies automatically. I think that function is being done quite well.

One thing I think would help, as I mentioned in the prepared statement, would be a more systematic system in which all proposals are filed in the Science Information Exchange. Thus every agency would more easily know who is receiving proposals, but it would then be possible to keep systematic track of what happens to them. At present, although they are efficiently referred from one agency to another, no one keeps a record of the overall picture.

Mr. VIVIAN. There are no guidelines which have been promulgated; there is no criterion which one follows on an established basis?

Dr. SHERWIN. Nothing written down, except, of course, the long-range plans and priorities based on relevance of each military department.

Mr. VIVIAN. What do you construe as the principal purpose of the research carried on by DOD? I do not mean research, for example, in supersonic aerodynamics, which very clearly relates to the various aircraft with which you deal, or, say, with certain types of research in electronics, which may be almost totally military in character. I refer to research in a field such as mathematics. I know DOD has done this in the past. Do you still carry on any research in mathematics today?

Dr. SHERWIN. Yes, quite a bit. We are one of the strongest supporters.

Mr. VIVIAN. What would you construe that that would do for the Defense Department that wouldn't be done equally well under NSF?

Dr. SHERWIN. As an example, I was just reading the Office of Aerospace Research description of their mathematical interest. They were discussing the importance of a particular class of differential equations which are related generally to military problems—control problems, and aerodynamics problems—to which they were giving priority. Also, we have heavily invested in the special areas of mathematics associated with the programing and use of digital computers.

Each of the three military contracting organizations has a plan which they call their research or their technological forecast or their guidelines for research, which indicate the areas of primary interest.

I could provide you with a set of each of these from each Department to give you an idea how they determine their program.

Mr. VIVIAN. Going back to the subject of mathematics again, I can construe several valid purposes for research in the agencies. Certainly one of them is to develop a field of science which is not necessarily unique but extremely important to that particular mission agency and which may have very little relevance to the other agencies, or for other purposes. A second purpose, I would say, would be the education of the staff of the agency. Certainly you must maintain your own staffs at a high level of understanding, and they can gain some of this education by having either in-house research or by contractor research which is delivered to them and which they absorb by merely being exposed to it. This is all right. The same thing is true of the contractors. As a practical fact, you can have no useful contractors without giving them work experience in the field in which you expect further work. From my point of view, this is a much bigger factor with respect to most development contracts than many people realize. However, I really don't see how the subject, for example, of research in mathematics fits very well into either of these categories. It would seem to me that this could be done very well, for example, by NSF.

Dr. SHERWIN. I am sure that parts of it could be. I believe, however, that I can identify certain areas of mathematics which meet your first criteria, namely, that they are extremely relevant to the problems that the Defense Department has and need encouragement by offering support.

As an example, the mathematics of linear programing which we have heavily supported might conceivably have received relatively little support emphasis from a pure-science-oriented organization. It has produced a manifold payoff for Defense. Let me cite a single specific instance. The Defense Fuel Supply Office annually picks successful bidders for the supply of over 200 million worth of jet fuels. One of the significant economic factors that had never been adequately taken into account was fuel transportation costs to various depots. The problem of minimizing total cost to the Government is a complicated one that must take this geographical factor and other cost factors into account. It turns out to be reducible to a linear programing problem. By application of this mathematical technique, with the help of modern high-speed computers, it has been possible to effect an estimated annual savings of $4 million. This is only one of many examples of the application of this versatile mathematical method. It even has direct military tactical applicability to such problems as optimum schemes of multiple bomb delivery by manned aircraft.

Another area of fundamental mathematics I suspect would receive less emphasis from a pure-science-oriented organization than it deserves in terms ultimate payoff to the taxpayer is that underlying the prediction of equipment reliability and assurance, statistical quality control, and process planning.

I hesitate to guess how many millions of dollars have been saved through the application, for example, of sequential sampling techniques in equipment evaluation and quality control. These techniques, going back originally to wartime work of the mathematician A. Wald, were early recognized for their defense significance and were used in

World War II as one of this country's secret weapons. Subsequent Defense-supported fundamental statistical research growing out of the early work has led to entirely new systems of inspection sampling, implemented by military standard 105 and its subsequent revisions, which now benefit also our allies in a NATO version.

About high-speed electronic computers, which have both drawn upon and contributed to fundamental mathematics, I need say very little. I am sure you are well aware that these devices, which already are having such an impact on our lives that they may be said to be ushering in the age of automation, were in their inception wholly supported, and are still today mostly supported, by Department of Defense fund sources. Not only are we still the primary source of support for computer technology and design, we are also the primary source of support for new and radically improved programing methods, including multiple access and new machine languages such as Militran.

Another area of mathematics receiving our strong support is nonlinear systems and adaptive control theory.

Indeed, our concern for relevance is so great that we turn down approximately 60 percent of the formal proposals made to us, and discourage many more in the state of informal negotiation.

Mr. VIVIAN. How does a contract administrator in DOD decide whether mathematics project "X" belongs in DOD or in one of the other agencies? I don't care which agency right now.

Dr. SHERWIN. Each of the agencies receives, first of all, comments by peers on the quality of a program for scientific quality. Then, in the case of the Army, these proposals are sent around to the Army in-house laboratories for evaluation comment on all proposals that come in. Then, they look at their overall plan for emphasis and growth in various technical fields. Combining those together, they make up their decision about support. So, if, for example, a university has a project in a mathematical area which looks like it is interesting or useful to one of the Army laboratory people, or in one of their projects or a project which they know about, which they often do, then, they would presumably get support. The other services do not send it out to the in-house laboratories, but they do examine the program in terms of the overall plans which I mentioned earlier, and which bias their decisions. So, there is a strong tendency toward relevance. Also, in each of the three contracting agencies there has grown up in the past several years a systematic effort to try to relate their research programs to their mission activities. They have seminars, discussions, and meetings, visits to laboratories, and so forth, trying to determine where are the areas of science which are most related and need the greatest support. There is a growing interest and concern with this problem, and mechanisms are being set up to improve the coupling between research and application. We must be cautious and not extend the relevance principle too far or too consistently, for we need diversity of support for new ideas and, if only one outfit can support a given class of ideas, then everything hinges on its wisdom.

Mr. VIVIAN. I should comment that people in the scientific community do not wish to have sole-source support. They much prefer to have several different agencies, so if there are human blockades, as there always are in every agency—perhaps a person who has a certain dislike for certain ideas—these people do not stop all worth-

while activity in that area. I am not objecting to this. I am trying to find out how you adjust the total volume. I gather the answer is that the machinery of adjustment is still somewhat uncertain.

I would like to come back to this subject of comments by peers. I believe NSF has a system by which proposals are evaluated by advisory groups of individuals in the same area of technology who are considered to be technically peers of the submitter. Do all the agencies of DOD have organized procedure for evaluation by peers of all research contracts?

Dr. SHERWIN. No. In fact, we support universities at a total level of about $400 million a year. This accounts for contract research centers, applied research and basic research, the general program type and the specific project type. Of this, $300 million is not involved in peer evaluation. This covers our contract centers, our applied research programs, and our general programs. Thus, three-quarters does not utilize peer evaluation.

Peer evaluation is involved in about $100 million, mostly specific projects. The peers are a rotating group in order to provide diversity. They give their individual comments and evaluations. In the case of the Army, the proposals go to the in-house laboratories for comment. In the case of the other military departments, they discuss them among themselves in the light of their overall plan. Thus, although the DOD staff uses peer evaluations, in about one-quarter of their total university program, they are only a part of the decisionmaking process.

Mr. VIVIAN. Are the memberships of these peer groups identified; that is to say, is it generally known in the industry who is the evaluating group?

Dr. SHERWIN. No, it is not. There is a large panel of people who are called upon, and different groups are called on for different cases. In many cases the Government evaluators in the central agency do not have the names of the peer evaluators involved in specific evaluations. They just see the results. It is a fairly objective method.

Mr. VIVIAN. I have a comment to make on the subject of ILSE. Is this computer so organized that it can be distributed to the public? In other words, is it available to the general scientific public?

Dr. SHERWIN. It can be done.

Mr. VIVIAN. Is there harm in so doing?

Dr. SHERWIN. Part of the work is classified, and that part of it would be deleted; otherwise, it could be done.

Mr. VIVIAN. But some of that is available to contractors who already have volumes of scientific classified information?

Dr. SHERWIN. Yes.

Mr. DADDARIO. Do I understand you correctly, that it can be done and is being done, or it can be done and is not being done?

Dr. SHERWIN. I must say I am not certain how wide the distribution has been. It is going, I know, to selected organizations and individuals that are active now in the field of life sciences being supported by NASA and DOD. It is not now going to a broader group. It is inexpensive to print out a format which would be suitable for public distribution and make it available to the public.

I am not sure that it would really be necessary. I think it is more important that the scientific community which is most directly involved has access to it for purposes of management and decision-making, and that is possible.

Mr. DADDARIO. And is being done?

Dr. SHERWIN. It is now distributed in a complete form to nongovernmental consultants associated with either the NASA or DOD life sciences programs. We are also giving the unclassified material to the Science and Information Exchange, which is widely accessible.

Mr. VIVIAN. I think that is something, Mr. Chairman, which we might ask to have looked into further? Is this desirable or advantageous to the many people who are putting in these proposals. In a sense, the major supporter of the life sciences is NIH. Is it involved in any way?

Dr. SHERWIN. Not at the moment. This is a DOD–NASA interchange. DOD and NASA have proposed to all the agencies in the Government that they join in a common digital language system which would permit an interchange on the basis of the R. & T. resume system. NIH has not yet joined, but we have had several discussions with them.

Mr. VIVIAN. Do they receive print-outs?

Dr. SHERWIN. We give print-outs to individuals in NIH, and are willing to transmit official copies if they request them. Also, we now give all the unclassified data to the Science and Information Exchange which NIH uses a great deal.

Mr. VIVIAN. Presumably, under research contracts virtually all the funds that are awarded are used for research purposes, including overhead requirements, and so forth. Under research and development contracts, which are often labeled development contracts to generate a specific end item, what percentage of them normally produce what is called research effort? It must be a sizable fraction.

Dr. SHERWIN. It is, and it is very hard to estimate. Indeed one of the primary sources of funding of the key advances that we have observed thus far did come from development contract money which was allocable by local agreement to applied research and even research problems that came up in the process of development. Research, particularly applied research, tends to get born where it is needed and where people get excited about it, and where there is a sense of urgency. At the moment we do not have a systematic method of sorting out from our development programs that part which is going into research. We feel that the R. & T. résumé system is well suited to this purpose since it is brief and flexible. You can take bits and pieces of programs which have research content, put them into the standard digital format and then relate it to all similar work wherever else it is being done.

Mr. VIVIAN. What number of dollars goes into development contracts per year?

Dr. SHERWIN. The R. & D. budget in Defense is about \$6½ billion, and of that only about \$1½ billion is in research and technology or exploratory development. About \$0.9 billion goes into

advanced development and $1.3 billion goes into engineering development.

Mr. VIVIAN. Of the development contracts, what would you estimate might be labeled as research by some reasonable standards?

Dr. SHERWIN. In the past or in the future? Let me speak first about the future. Because there has been a very important shift in policy in Defense in which engineering development requires, whereever possible, fixed prices and predictable performance. The new rules are that you must have the technology and the scientific facts well in hand before starting. Engineering development is our major category, over $1.3 billion a year. Under these conditions we will expect very little research and applied research to be done. It shouldn't be necessary at that stage. However, we do expect a substantial amount to be done in advanced development. This category is running at a little under $1 billion a year. My opinion is that it would be entirely reasonable to have 10 or even 20 percent of the money in the advanced development stage available for closely related research or applied research. This is just the area in which our studies have indicated applied research is most effectively done—when you are in the early stages of a development program when you are not yet aiming at a fixed time deadline, when you are not committed to production, and when you are trying to show feasibility of a new concept.

Mr. VIVIAN. I concur with your comments. That would suggest an additional $200 million to research.

Dr. SHERWIN. Part of that money could be obtained by merely allocating part of our exploratory development funds for this use. Part could be obtained from the larger expected savings in engineering development. Thus, it would not necessarily require an increase in the total R. D. T. & E. funds.

Mr. VIVIAN. I have seen a series of statistics earlier which left me with the conclusion that it did not reflect very accurately to my knowledge the situation as it exists. I think that once certain labels were applied to these funds, from then on they go through the tabulations with no further inspection.

Let me come down to procurement funds. Under procurement funds presumably relatively little research was done, although there have been famous contracts in which research was done in the past. How about the future?

Dr. SHERWIN. One of the sources of overruns is the fact that this has occurred, often from necessity. Presumably, in the future this would happen very infrequently because the procurement would be committed against a fixed price contract and based upon on-the-shelf technology. I am not sure that some technology work won't be necessary, for no prediction is perfect, and unforseen problems will arise.

Mr. VIVIAN. I have two other questions. The first one is on the geographic distribution of research funds. It is my understanding that there is no policy in force within the Defense Department relevant to geographic distribution.

Dr. SHERWIN. Right.

Mr. VIVIAN. At no time is a contract administrator given any instructions to consider geographic distribution in his efforts?

Dr. SHERWIN. I believe that is correct.

Mr. VIVIAN. Would you estimate that any significant fraction of the DOD contract awards are given at a time when the selection between the top several contractors is at best somewhat murky or rather difficult to decide?

Dr. SHERWIN. I am sure it often happens.

Mr. VIVIAN. Like quite frequently, for example?

Dr. SHERWIN. Yes; it probably does.

Mr. VIVIAN. Under these conditions when the technical criteria and the administrative criteria and the management criteria are at best hard to differentiate, to put it mildly, do you think the geographic consideration is totally inappropriate, or would you rather not answer that question?

Dr. SHERWIN. I certainly feel that I should not speak for the Defense Department on this important policy issue.

Mr. WAGGONNER. Could I interrupt there?

Mr. DADDARIO. Mr. Waggonner.

Mr. WAGGONNER. It is safe to say that the Defense Department is concerned with maintaining a certain amount of potential productive capacity the Nation over for times of emergency, isn't it?

Dr. SHERWIN. Yes. They have a number of standby plants, all of them maintained for this purpose.

Mr. VIVIAN. They do not maintain standby research and development plants that I know of.

Mr. WAGGONNER. Of course, they don't have a lot of in-house capability there.

Dr. SHERWIN. We have quite a bit in-house. We have over 30,000 scientists and engineers in the Defense Department. A great fraction of them, 20,000, are in laboratories and technical organizations distributed all over the country, although largely on the east and west coasts.

Mr. VIVIAN. And Dayton?

Dr. SHERWIN. Dayton, Ohio, being the largest exception.

Mr. VIVIAN. There are a very large number of contracts that usually come down to the wire in which the person making the contract decision wished there were greater differentiation between the contractees so he could make a better decision. Under these considerations geographic distribution is a rational consideration. I think this is done sometimes by the Defense Department, but I believe it is done without any guiding principles where someone can be pinned down on it. This is where my concern lies. I do not believe there is any policy to guide a contract administrator whereby if he followed it, he would be considered as acting in the Government's interest, or where if he violated it, he would be considered as acting against the Government's interest. The lack of policy is what concerns me.

Now, my last question. The quality and quantity of scientific manpower left much to be desired in some years past, and we have put forward an effort during the past decade to train and develop more talent. This was referred to by the previous speaker a few moments ago, particularly in reference to Dick Bolt's model.

Has DOD generated anything which you would call equivalent to a mathematical model for predicting its needs in technical manpower in various levels of quantity and quality which would in any way relate, for example, to the one referred to a few moments ago?

Dr. SHERWIN. I believe there are no mathematical analyses like this. Dick Bolt's article, which I scanned when I saw it, is the first of this type to my knowledge. We have studies and analyses and plans, but they are currently made without mathematical models.

Mr. VIVIAN. My estimate of the forecast information available from places like the Library Congress, which is, of course, a collection agency as well as a generating agency, is that the prediction information available on which to base further educational programs is, to put it mildly, exceedingly qualitative. It could be that we need fewer, or more, or the same number, but we will never know it from anything that is available to us today. While they may be wrong, they may also be right. I would appreciate it if there is any information in DOD which leads to a wise understanding of what the future needs will be.

Dr. SHERWIN. I will inquire to see if there is any new type of work going on that would have the kind of an approach that you mentioned. (Note for record: I have inquired and found there is none.)

Mr. DADDARIO. Just following that a bit, does DOD look to the National Science Foundation as the source from which it can derive, or should derive, or does derive, its scientific and engineering manpower information?

Dr. SHERWIN. Their reports are the national standard of information in this area. We use them to the degree that they are related. So, we use them all the time.

Mr. DADDARIO. You see this as being an important function of the National Science Foundation in respect to your work?

Dr. SHERWIN. Oh, indeed, it is. Also, the ability to make better predictions and to make more accurate up-to-date evaluations of the numbers of people is greatly to our interest. We would be very much in favor of seeing an even better job than they are doing now. They are doing a very valuable job. I listened to Dr. Wolfle's testimony, and would agree that we could easily use better data, and we would find it very valuable.

Mr. DADDARIO. You talk about better and more up-to-date data, and you agree with Dr. Wolfle in that regard. Do you have any examples of information that you now need, and which NSF could supply, but which is not available to you? Is there a vacuum in this field?

Dr. SHERWIN. I am not familiar with it in detail, but I could give you one example of an answer which we are interested in. We would be interested in knowing with respect to all the Defense grants given to universities and all the graduate students thereby supported how many students later contributed to the Defense Department programs. This kind of questioning could come out of a manpower survey that had adequate data base. It could be pulled out automatically if they had the information there. We could trace these people back, determine their support, and determine the way in

which we have benefited by our indirect support to graduate education.

Another interesting point. When people do graduate work they tend to have one great fault, or perhaps a virtue; they very often tend to continue to be interested in the same field. Thus if we interest people in, say, optical physics because we support it and because it is unusually important to Defense, we tend to produce people that would like to work in optical physics. We can hire them, therefore with relative ease to do work either for contractors or in the Government laboratories in optics programs. However, a student trained in high energy physics generally wants to do high energy physics and not optical physics. They could easily enter optical physics as far as their basic training is concerned, but their motivation is weak. Thus, the type of DOD support is biasing the interests of the graduate students toward our interests. In this manner, an emphasis on relevance may have very interesting extra consequences. An agency's interest and in heavy support of a given area tends to perpetuate the production of people interested in that area. The degree to which this has happened could be determined from adequate manpower records.

Mr. DADDARIO. What you are saying is that the information would be helpful so that you would know what manpower is available. In addition, if you added to that a label to show what contribution you made to getting them into this stream of activity, it would support the programs you now have, and thereby serve a double purpose.

Dr. SHERWIN. Suppose we could prove that the people we educated, so to speak, by indirect support of their thesis turned out to be an unusually high fraction of the people working on defense programs. This would seem to me to be an excellent argument for the mission-oriented agencies carrying on research in the universities. We do not have any evidence of it now. It might be positive or negative. I suspect it might be positive. The facts could only be obtained by a careful survey.

Mr. DADDARIO. Could we label all these people as DOD, NIH, or NASA?

Dr. SHERWIN. You could trace their history and determine the way it ended up, the way their careers were directed in the support of various Government mission activities or other activities. The ability to trace people and their activities in areas of interest to defense would be very useful. Incidentally, this is expected to be one of the consequences of the R. & T. résumé system. It breaks down the activities that are going on in such detail and gives the name of the principal investigator actually doing the work and the secondary one. Since, on the average, the work unit is so small, in most cases this is the whole staff on the work unit being reported. With our new digital historical files, we can trace back and find out where people worked, what contribution they made, what kinds of fields they were in.

If this were a standard Government-wide reporting system, then we could find out wherever people supported the Government, and in what way. This would take time, for the records must be built up. Five years from now we could play back the history of how people participated in the Government in the last 5 years.

Mr. DADDARIO. You are talking about an information system which would be so complete that it would provide all of the information you need, and the more information the better.

Dr. SHERWIN. You have to be careful about collecting information that won't be useful. If the information has enough detail to give an accurate breakdown in terms of technical fields, then the same information will also give very naturally very useful data on manpower inventory and flow.

I might add if for the last 10 or 20 years we had the records that the R. & T. résumé system will give us, we would be able to reconstruct the origins of the key contributions of research and technology to defense with much greater ease than is now possible.

Mr. DADDARIO. Do you see the National Science Foundation as being the agency under which this data could be assembled for assimilation to all the other agencies?

Dr. SHERWIN. The beautiful thing about the research and technology résumé system is it is a digital system. It has a common set of codes and definitions and therefore it can be stored and handled anywhere in the Government, permitting complete economical and almost instant interchange. There is no need for a central file. You can interrogate 15 agencies against the same set of data and bring together any information you want. If they speak the same language, the same digital meanings to all the words, and they are made against a common set of definitions and codes, then any agency can assemble and process any data it wants. It makes a very flexible tool. It can provide centralized knowledge but avoids the centralization of control in processing.

Mr. DADDARIO. Including industries?

Dr. SHERWIN. Including industries, providing we meet the requirements of security and proprietary information.

Mr. VIVIAN. If you have 30 seconds, Mr. Chairman, I would like to interject a comment. I have known Chalmers Sherwin for well over a decade. I think he is a very able person, exceptionally so, and the public is to be complimented for having gotten such an able person on its staff. I apologize for using your time, but I did want to take advantage of this opportunity.

Mr. DADDARIO. I am pleased you have.

You can tell Dr. Brown if he is not careful and sends you around too much, we might be asking for you in the first instance.

Dr. Sherwin, I am sure we will have a whole series of questions to send to you, and I hope you will be able to answer them for the record.[1] We cannot cover all the points that we would like to in the time available.

I want to thank you for your appearance.

This committee will adjourn until 11 o'clock next Tuesday at this same place.

(Whereupon, at 12:15 p.m., the meeting was adjourned to reconvene at 11 a.m., Tuesday, July 6, 1965.)

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

TUESDAY, JULY 6, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10 a.m. in room 2325, Rayburn House Office Building, Washington, D.C., the Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. This committee will come to order.

Our witness this morning is our distinguished Chairman of the U.S. Atomic Energy Commission, Dr. Glenn T. Seaborg. Doctor, would you proceed, please.

STATEMENT OF DR. GLENN T. SEABORG, CHAIRMAN, U.S. ATOMIC ENERGY COMMISSION; ACCOMPANIED BY DR. GEORGE KAVANAGH, DEPUTY ASSISTANT GENERAL MANAGER FOR RESEARCH AND DEVELOPMENT, AEC; DR. JACK VANDERRYN, TECHNICAL ADVISER TO THE ASSISTANT GENERAL MANAGER FOR RESEARCH AND DEVELOPMENT, AEC; AND GEORGE W. COURTNEY, JR., ASSISTANT TO DIRECTOR FOR PLANS AND POLICY, DIVISION OF NUCLEAR EDUCATION AND TRAINING, AEC

Dr. Seaborg. Mr. Chairman, members of the subcommittee, it is a pleasure to appear before you this morning. I am flanked here by Dr. George Kavanagh on my left, Deputy Assistant General Manager for Research and Development for the Atomic Energy Commission, and Dr. Jack Vanderryn, Technical Adviser to the Assistant General Manager for Research and Development.

Mr. Daddario. We welcome both of you gentlemen.

Dr. Seaborg. I am very pleased to be here today to tell you about the relationships between the Atomic Energy Commission and the National Science Foundation. The Foundation's activities have a significant effect on the well-being of science, technology, and education in the United States. This, in turn, is important to the successful conduct of the Atomic Energy Commission's programs. Further, as a scientist and an educator, I have a very strong personal interest in the activities and programs of the National Science Foundation. Therefore in addition to discussing with you the specific relationships of the AEC to the NSF, I would also like to comment more generally on the programs of the Foundation.

51-204—65—vol. 1——14

Basic Research

The National Science Foundation is charged with "the support of basic scientific research * * * to strengthen scientific research potential in the mathematical, physical * * * and other sciences * * *." This NSF support is without regard to eventual usage or application of the results. The mission-oriented agencies such as the Atomic Energy Commission specifically require advancement of knowledge in generalized but nevertheless somewhat more restricted areas of science and technology. As is the case with the AEC, proposals for research are funded by NSF on the basis of scientific merit. Because such funds are limited, only the highest quality proposals are supported by each agency and many meritorious requests must be rejected.

The future development of knowledge in areas of science not supported by a mission-oriented agency may well be of prime interest to that agency. Nevertheless, these agencies must place their major emphasis in areas of recognized need. When a "breakthrough" occurs in other areas, then the mission-oriented agency steps in to give the required emphasis. A recent example of this, concerning the AEC, was the study of superconductivity which might have appeared to have no application in its program. With the finding of magnetically hard superconductors and potential application in producing magnetic fields for use in controlled thermonuclear and high energy physics investigations, became immediately evident and our involvement in the field resulted. Thus, the mission-oriented agencies require strong national support of non-mission-oriented research. I can also cite an important example which illustrates the unexpected and broad benefits which can result from mission-oriented basic research.

In 1962 scientists working at our Argonne National Laboratory, following a lead from research results obtained by Prof. Neil Bartlett at the University of British Columbia, discovered that xenon, a so-called inert or unreactive element, could combine simply with fluorine. This has opened up a whole new field for both experimentalists and theorists. The work grew out of AEC's interest in the chemistry of fluorine and of the fission product gases such as xenon.

These two examples illustrate my contention that it is important to the continued strength of science in this country for both NSF and the mission-oriented agencies to continue their vigorous support of basic research. The emphasis at NSF should be on support of broad-based university research, whereas the AEC will continue to use both its own laboratories and the universities, as appropriate.

The AEC, like the NSF, makes extensive use of the scientific community in reaching decisions on supporting unsolicited proposals for basic research in the physical and life sciences. After first determining that the subject of the proposal is of interest to the AEC, an average of three scientific reviews in depth are requested of outside scientists known by our scientific staff to be working in or knowledgeable of the subject in question. That is, the proposing scientist's project is judged by his peers and we are assured of a continuing high quality in the projects we support. Final decisions

on acceptance of a proposal are made by the AEC staff taking into account the opinions and recommendations of the outside reviewers and our degree of interest in the subject matter of the research.

AEC–NSF Relationships

COORDINATION OF SCIENTIFIC PLANNING AND PROGRAMS

Our principal relationships with the National Science Foundation occur in two areas—in basic research in the physical sciences and in education and training programs. The largest NSF expenditures are generally in these two areas, whereas the education and training activities of the Commission are allocated less than 1 percent of our R. & D. budget. About 16 percent of our R. & D. expenditures are for basic research in the physical sciences.

PHYSICAL RESEARCH

In the physical sciences area the AEC has very close relationships with the National Science Foundation for the support of basic research in nuclear physics, metallurgy and materials, chemistry, solid state science, and certain phases of engineering research. Several methods are used to coordinate our interests in the support of basic research. First of these are two formal interagency Committees established under the auspices of the Federal Council for Science and Technology—the Technical Committee for High Energy Physics (TCHEP) and the Coordinating Committee for Materials Research and Development (CCMRD). These Committees include both NSF and AEC membership (the Chairman of the TCHEP is Dr. Robertson of NSF) and meet periodically to review scientific, budgetary, and administrative problems in the support of research in their respective areas of interest. These Committees serve a very useful and important purpose in the effective coordination of important areas of research. Secondly, the AEC and NSF both have representatives on the Solid State Sciences Panel of the National Research Council of the National Academy of Sciences (NAS–NRC) and both have liaison representatives to the Division of Physical Sciences and the Division of Chemistry and Chemical Technology of the NAS–NRC. These divisions of the NAS–NRC, working with the various agency representatives, serve as one of a number of means of communication with specific segments of the scientific community. The Solid State Sciences Panel, for example, is composed of senior scientists from all segments of the American scientific enterprise—industry, university, Government and not-for-profit laboratories, and the research-sponsoring agencies.

Twice yearly the Panel meets at a center of scientific activity to learn about the research conducted at that center and to hold a business meeting at which substantive issues affecting this area of science are discussed. The Panel forms a very effective bridge between Government and the solid state sciences community at large for exchange of points of view, identification of problems affecting the national health of the field, and for proposing the direction of future

scientific activity. Both NSF and AEC, as well as other agencies, are represented on this panel.

In addition to these formal Committees there are about eight informal interagency groups concerned with program coordination in such areas as nuclear structure physics, information systems, metallurgy, chemistry, and engineering research. At least three of these informal groups were established at the suggestion of the NSF. In the chemistry area for example, a group known as the Federal interagency chemistry representatives meets to exchange information on program status and problems involving more than one of the agencies. Meetings are attended by representatives from each agency having idenifiable basic chemistry programs in universities. This group was formed about 1952 by Dr. Kirner, retiring head of chemistry programs at the NSF. It has been effective and has helped avoid many of the possible pitfalls in Federal support of basic research in universities. At the most recent meeting, a committee report on AEC-supported chemistry research at universities was discussed as well as more general questions dealing with university research such as support of an investigation by a single agency versus several agencies; policies on payment of faculty summer salaries, support of foreign travel: and ratio of proposals received to those accepted.

The AEC and the NSF are the agencies principally involved in providing low-energy accelerators to universities. Proposals are jointly discussed and decisions reached regarding the strongest proposals and as to the agency which will provide support to a given proposal if funds become available. For example, several years ago both the AEC and NSF had proposals from a number of universities for new tandem Van de Graaff accelerators. It was jointly agreed that the three top proposals were from Rochester, Yale, and Minnesota. It was further arranged that the NSF would support the Rochester proposal and the AEC support the Yale and Minnesota proposals.

In the nuclear physics area we feel it is important that the NSF have the capability and the willingness to provide more support to the smaller schools—to provide the seeding and encouragement to those institutions which are not presently competitive in quality of research with the major universities. We emphasize the support of technical excellence in research. As part of this process we have been able to help the further development of such institutions as the University of Maryland, University of Colorado, and University of Oregon. In these cases the AEC has provided accelerators around which have developed, or are developing good nuclear physics research programs. We do, therefore, have several examples where we have recognized good potential, and by providing research support have brought these programs to the forefront of excellence. However, we still find that a large number of colleges and universities are unable to obtain Federal support for nuclear physics because they are too far from the top in the quality of their proposed research undertakings.

I favor the initial thrust of the National Science Foundation's science development program of placing high-ranking institutions even

closer to the top since it is a most efficient way of developing additional excellence rapidly. This is absolutely necessary if we are to keep up with the education of the rapidly increasing student population and at the same time carry on sufficient high-quality research. Thus, I can only conclude that additional funds are required for NSF in order that some seed money can also be provided to the lesser recognized institutions to build up their capabilities in specific areas such as nuclear physics. Perhaps one way to accomplish this is a considerable expansion of the science development program to permit the rapid development of a much larger number of institutions than is possible with the Foundation's current budget.

In the fields of physical research such as chemistry, metallurgy, and physics and also in certain areas of fundamental engineering research there are very frequent contacts between NSF and the AEC which are in addition to the formal and informal committees or groups which I mentioned earlier. Lists of proposals received and of actions on pending proposals are routinely exchanged each month. Telephone contacts between the AEC and NSF individual program administrators occur very frequently, sometimes almost daily, for final checks before actions are taken on proposals in those cases where an investigator has submitted proposals to both NSF and AEC. For proposals still under review by both agencies, discussions take place on scientific content of proposed programs, proposed equipment purchases, fraction of the investigator's time to be spent on the research, etc.

Quite often the technical reviews of a given proposal will be exchanged or discussed to insure the maintenance of quality standards, to obtain a broader evaluation, or to reduce the burden on the scientific community which reviews the proposals.

The matter of multiple-agency support to individual university scientists is a matter of increasing interest, especially in the chemistry and materials sciences areas. The solid state physics program staff of the NSF has recently taken the initiative to bring solid state physics administrators of all agencies together on an approximate monthly basis and has become the focal point for collection of work statements and budgets for all Government contracts and grants to universities in this area of science. The NSF staff has analyzed the data, and the agencies are working together to reduce multiagency support of individuals and thereby reduce chances of overfunding, overlap of support, and similar problems. Upon receipt of a new or renewal proposal, an agency administrator can telephone NSF and receive a fairly accurate statement of the proposer's other Federal involvements and commitments. Representatives of the Science Information Exchange (SIE) attend these meetings. The solid state physics administrators are now developing a coding so that the system can be questioned regarding the amount of money going into subcategories of this broad field of science. This enables studies to be made of the relative level of support of the several subcategories. It is anticipated that the system data will be fed into the SIE and it may serve as a model for other fields of science.

BASIC NUCLEAR ENGINEERING RESEARCH

About 3 or 4 years ago, the academic nuclear engineering community began expressing its dissatisfaction with the Federal support picture for basic nuclear engineering research. The prevalent feelings were that in the AEC such research proposals fell in a "gray" area between basic research and applied research, and were accepted by neither program area; and that a similar situation existed in the NSF with respect to its Physics Section and Engineering Section. These feelings were summarized and formally expressed in a report prepared and submitted to the AEC by a group of representatives of several professional societies and organizations.

Therefore, the AEC included in its fiscal year 1964 and fiscal year 1965 budgets requests for funds to provide for a separate category under the physical research program entitled "Basic Nuclear Engineering." In fiscal year 1964, this item was deleted by the House Appropriations Committee; in fiscal year 1965, it was deleted by the Joint Committee on Atomic Energy. The JCAE stated in its authorization report that it believed the necessary research could be conducted under the Commission's existing programs. Thus, nuclear engineering research proposals continue to be accepted for review within existing programs, as they have been in the past. The criteria used in evaluating these proposals are generally the same as those used in evaluating other proposals received by the program divisions concerned; that is, relevance to AEC interests, and scientific merit.

At the present time, the Commission's applied programs support about $3 million worth of research in universities' engineering and physics departments. Additionally, our basic research programs support a substantial volume of research in engineering departments as universities, but it must be admitted that this research is more science oriented than engineering oriented, which is a consequence of the nature of the proposals submitted by these departments.

It is true that in the past few years the university community has found it difficult to obtain support for new proposals, particularly in the areas of nuclear engineering and basic reactor physics. As much as anything, however, this has resulted from an insufficient amount of funds to satisfy all needs coupled with our assessment of relative priorities. We will, of course, continue to try and support outstanding research proposals in these fields. However, in view of this situation, and the overall benefits of such research, we suggest that it would be quite appropriate for the NSF, in its role as the balance-wheel for support of scientific activities, to request increased funds for university research in nuclear engineering. This would be entirely consistent with the statement in the Legislative Reference Service's report to this committee which states "the responsibility for any expanding Federal support of basic research may increasingly be thrust upon non-mission-oriented agencies." I will have more to say about a related aspect of this problem a little later.

To summarize our relationships in the support of basic research in the physical sciences, therefore, I should state that, of all of the agencies concerned with support of basic research in this area,

the one with which AEC has the most frequent contact is the NSF. Invariably we have found the NSF cooperative and anxious for close coordination.

EDUCATION AND TRAINING ACTIVITIES

I would now like to turn to the second major area of AEC–NSF relationships: education and training activities. NSF–AEC interactions in this area are also very close, especially since we have one program which is jointly funded by the two agencies. The specific educational programs which each agency undertakes are the following:

First, AEC has a program of nuclear teaching equipment grants to colleges and universities. Major emphasis in the AEC program is to provide equipment for the training of graduate students; our secondary interest is in the training of advanced undergraduates. To date we have provided equipment to about 650 institutions, from junior colleges to universities which are among the major graduate centers in the country. The NSF, on the other hand, provides equipment grants to similar institutions, but for all fields of science and solely for undergraduate teaching. AEC and NSF staffs periodically review lists from requesting institutions to identify duplications. In the few cases where duplications appear, only one agency makes the award. At the undergraduate level, AEC frequently refers the proposer to NSF for possible support and NSF may refer a proposal to the AEC if it is completely nuclear or graduate oriented.

This coordination works smoothly. To an increasing degree, NSF is providing nuclear equipment to those proposers where such equipment is only a minor part of a general-science program as contrasted to a nuclear-science program. This is beneficial to the individual institution, and permits us to concentrate our funds on those programs having greater relevance to our specialized mission. There are, however, not sufficient funds in AEC and NSF to meet all the educational needs in this area.

Secondly, AEC administers fellowship and traineeship programs in specific areas related to atomic energy program manpower needs: fellowships and traineeships in nuclear science and engineering, and health physics and industrial medicine fellowships. We also have AEC laboratory graduate fellowships and postdoctoral fellowships which provide for research experience in AEC facilities. The postdoctoral fellowships are primarily for individuals interested in teaching nuclear science and engineering. Our policy restricts fellowships to individuals whose stated intent is to prepare for atomic energy-related careers. It might be of special interest to this committee to mention that we recently instituted a traineeship program in order to further develop institutions which have qualified graduate programs in nuclear engineering but relatively low graduate enrollments in this field. We provide funds which permit the institution to bring in fellowship students. This tends to avoid the concentration in a few universities which occurs when the fellows select the institution they wish to attend.

Several times a year a meeting of all Federal fellowship administrators, together with a few invited administrators from national fellowships programs sponsored by private funds, is convened under the nominal chairmanship of the NSF fellowship administrator. Information is exchanged relative to past year's performance and plans for the following year. Appropriate levels of stipends, dependency allowances, and educational allowances in lieu of tuition and fees are discussed. The meeting serves as a general clearinghouse for information exchange and problem discussion. It is not formalized, binding decisions are not reached. Relative to AEC–NSF specifically, a continual informal exchange of statistical data, plans, and existing or anticipated problems is maintained. Our administrative procedures for fellowships and traineeships are kept as identical to NSF–NIH–NDEA procedures as is feasible.

The third program, and the one in which the two agencies have joint participation, is the faculty institute program. The AEC administers two parallel programs—first, short topical conferences for undergraduate and graduate faculty of engineering institutions, fully funded by AEC working through the American Society for Engineering Education and, secondly, AEC–NSF faculty institutes and conferences for college and high school faculty in specialized topics such as radiation biology or isotope technology. Proposals for the AEC–NSF institutes are submitted to both agencies. The NSF panel review system is used for selection of the host institution. At present, AEC's role in this selection process is minimal but we hope to increase our participation in the near future. AEC contracts for the operation of the courses by the host institutions, whereas NSF provides stipends and dependency allowances for the participants. This jointly sponsored program constitutes about 10 percent of the approximately 400 or more institutes supported each year by NSF alone.

The jointly funded institutes are beneficial to both agencies and therefore to the educational community. They provide for programs that might not be possible through single agency funding. This widens the impact of atomic energy upon science curriculums at all levels, enhancing the NSF mission and contributing directly to the AEC mission.

Finally, the support of nuclear reactors at universities is of interest and concern to both agencies. Nuclear reactors on the university campus may be utilized both for teaching and research. In August 1956 the AEC established its educational assistance program which, at that time, included provision for grants to schools to obtain low-power nuclear reactors for use in education and training. The AEC contribution toward each such reactor was subsequently limited to $150,000. Grants totaling $3.6 million were made for 32 of these teaching reactors. In addition, our educational assistance program provides for the loan of fuel for these reactors, as well as for university research reactors, at no charge for use or reprocessing. We also provide other associated reactor materials without charge.

However, we no longer make grants for the construction or purchase of teaching reactors. In 1956, there was informal agreement between the AEC and NSF that NSF would assume responsibility

for the support of university research reactor construction and that AEC would retain concern for the specialized training reactors. This agreement recognized the primary interest of the NSF in basic scientific research in all areas of science, particularly on the university scene, and the broad, interdisciplinary nature of many research programs built around a reactor.

In the period, 1956–60, NSF awarded 14 research reactor facility grants to 11 universities, at a total cost of $4.5 million. Beginning again in August 1961 to the present, there have been six grants to five universities, totalling $1.5 million. Only two of these grants—Berkeley, Oregon State—were for the establishment of totally new reactor projects. In addition to these mechanisms for the support of research reactors, both agencies fund certain research activities in which the university reactors are either the major subject of the research, or contribute to the research as an experimental tool.

We have found, however, as in the case of basic nuclear engineering research mentioned earlier, that neither agency has been able to support the use of these university research reactors at the levels desired and recommended by the academic community and by a panel of experts convened by the National Academy of Sciences-National Research Council under NSF sponsorship. This panel, which issued its report in October 1964, recommended that "the interested agencies consider the possibility of funding jointly the major portion of the operating costs of those university reactors making (or showing promise of making) a significant educational and research contribution to science and technology." The panel indicated that there have been 362 master's and 185 doctor's degrees granted to students using the 25 reactors surveyed, through December 1963.

The NSF and the AEC are continuing to examine this problem of support but both agencies are finding it increasingly difficult to provide the funds requested in the face of increasing demand for support in other areas coupled with the receipt of highly meritorious requests for support in these areas. Our relationships with NSF in this area have been excellent; there is complete interchange of information and ideas.

OTHER AREAS OF NSF–AEC INTERACTION AND COOPERATION

I have just described in some detail the two main areas of interaction between our two agencies. Let me now briefly mention some other areas of interaction. With respect to our relationships in biomedical research, it has been accepted and enthusiastically endorsed that support of the broad field of systematic biology is a prime responsibility of the NSF. Molecular biology, genetics, developmental biology, and metabolic studies are areas of common interest and thus lead to considerable contact and interchange. Some of our scientific staff members (from our Division of Biology and Medicine) are observers on NSF panels in the fields just mentioned. This participation involves review of NSF research proposals and also serves as an excellent interchange of program information and contemplated actions on proposals between the two agencies. Contacts and infor-

mation interchanges in these areas of common interest are very satisfactory and are similar to those which occur in the physical sciences, which I have already mentioned. In the life sciences area, however, our prime contacts are with the NIH rather than with NSF. On a multiagency basis, AEC professional staff serve on a large number of interagency committees or subcommittees—at least a dozen such groups—on which there is also representation by NSF. Such groups are generally very effective in providing for the exchange of scientific information, for assisting in the Government-wide planning of research efforts and selecting areas for emphasis, and for coming to general understandings about individual agency programs.

We, of course, have other, much more limited interactions with NSF in providing data on R. & D. funding levels, getting NSF assistance on manpower surveys, in the technical information area and in other staff-type relationships.

THE FUTURE ROLE OF THE NATIONAL SCIENCE FOUNDATION

Before closing, I would like to discuss briefly the overall activities of the Foundation and to suggest some areas for further emphasis. As Dr. Haworth stated in his introduction to the Foundation's annual report for 1964, "* * * continuing progress in science and technology is essential to the public welfare * * *." In this age of the scientific revolution I believe it necessary that strong and increased support be given to the activities of the NSF. Dr. Waterman and Dr. Haworth, my former colleague on the Atomic Energy Commission, both deserve the highest praise for their inspired leadership of the Foundation. As a single organization the Foundation cannot be expected to take the leadership in all aspects of the support of science in this country.

It should be abundantly clear that the various mission-oriented agencies each need to continue their support of applied research and development, basic research, and related education and training. The diversity of support for such activities, while it has been questioned by some, is one of the main reasons for this Nation's current scientific leadership. But the needs are great, and it is becoming increasingly more difficult for the mission-oriented agencies to provide the required support for basic research. In the AEC, because of competing mission demands, our budget for basic research is not structured to take advantage of many worthwhile opportunities, and neither can it provide for increased education and training opportunities which must be provided in order to maintain this Nation's scientific and technological leadership.

It thus must fall, in large part, upon the National Science Foundation to support those areas of research not now receiving adequate attention, and to provide for additional educational opportunities for high school undergraduate and graduate students and faculty in the sciences. Improvement in the quantity and quality of scientific research in the Nation's colleges and universities is an important ingredient for the improvement of the educational activities of these institutions.

Research and teaching are closely related. Historically, scholars have found that teaching, without research, can become static and sterile. I recall the dynamic role of the research in my own teach-

ing experience. I found that, during the years I taught nuclear chemistry, I did not use the same lecture notes twice.

I was engaged in research, and the field was advancing rapidly. It was possible for me to transmit to my students new knowledge and new laboratory techniques as they unfolded. Distinguished research by the teaching faculty has been an essential source of the greatness of universities, and it should endure as a measure of academic excellence in the foreseeable future. In the recent hearings, chaired by Congressman Reuss, before the Research and Technical Programs Subcommittee of the House Committee on Government Operations, it was the overwhelming consensus of all the witnesses, both from the academic community and the Government, that Federal research support on the university campus has done much to improve both graduate and undergraduate teaching.

Thus, the Foundation should be provided with additional funds: First, to support the highest quality research; second, to support research projects at some of the institutions now less well known for research; and third, to expand its program of science development grants and its so-called institutional base grants program, which would give the educational institutions the flexibility to use funds according to their individual needs. Serious considerations among the other science-supporting agencies are also underway to assist in the goals of these last-mentioned efforts.

I would also urge additional efforts in curriculum development. I had the great pleasure of personally participating in one of the efforts to improve the chemistry curriculum in the secondary schools, the so-called chem-study. These efforts have been very successful, and should continue to be supported. After all, a teacher's inspiration at an early age has been found to be one of the most important factors in turning young people to science. However, the young people who have benefited from these course improvements are now entering our colleges and universities and thus I believe that there should be increased emphasis to improve and develop the higher education curriculums. This is a logical outgrowth of the initial efforts.

I have only mentioned a few of the Foundation's programs. I do not mean to imply, by lack of reference to other NSF programs, that I consider them unimportant.

I can assure you that the AEC will continue to do its part in strengthening science and science education in this country.

In closing, let me restate that our relationships with the National Science Foundation have been most amicable and cordial. A number of cooperative arrangements exist and work well. Many formal and informal means of cooperation and interchange exist and are frequently used, some almost on a daily basis. We are very pleased with the effectiveness of these relationships.

Mr. DADDARIO. Thank you, Dr. Seaborg. Mr. Chairman.

Mr. MILLER. I want to congratulate Dr. Seaborg on this statement. I have found it very interesting and refreshing. I want to thank him also for taking time out of a very busy schedule to give us the benefit of his long experience.

Mr. DADDARIO. Thank you, Mr. Chairman. Dr. Seaborg, you stress the importance of a teacher's inspiration to the students at an early age. I wonder if you might tell us your idea how these fellowships,

which the Government gives, ought to be handled in regard to their teaching loads. I have gotten some indication from the academic community that the fellowship recipients shy away from teaching to an inordinate degree, and that the people who teach are the less capable people and, therefore, there is less inspiration.

Dr. SEABORG. I think the fellowships should be awarded in such a way that they can contribute to the teaching function. I believe that the fellowships for graduate students should in all cases allow for teaching experience by the graduate student during his graduate career. I also think that the fellowships awarded to teachers for the purposes of bringing them up to date in their fields should pay attention to the teaching experience and teaching role of the recipient as well as the research role.

Mr. DADDARIO. How does the AEC handle its fellowships in this regard?

Dr. SEABORG. The AEC permits and, further than that, emphatically encourages, teaching by the recipients of its fellowships.

Mr. DADDARIO. It was my understanding from a discussion with Dr. Haworth that the National Science Foundation, in order to stimulate its fellowship participants to additional teaching, allowed the universities to grant up to a thousand dollars for teaching obligation. When they did this, the number of people who taught in the fellowship areas jumped up from about 10 percent to 25 percent. Do you have such a requirement, and, if so, what is it?

Dr. SEABORG. Yes, we allow the institution to pay the fellow or trainee for teaching up to a maximum of $1,000 per year. We also have in our traineeships and fellowships a part of the monetary stipend that goes to the university—do you remember how much it is?

Mr. COURTNEY. We are allowing an educational allowance of $2.500 per student, in lieu of tuition and fees.

Dr. SEABORG. $2,500 per student goes as an educational allowance. That was Mr. George Courtney of our Division of Education and Training.

Mr. DADDARIO. $2,500 directly to the student as an educational allowance?

Dr. SEABORG. No; to the university to be used by the university to strengthen its programs, which can include the teaching function.

Mr. DADDARIO. Dr. Seaborg, might a greater obligation be placed on the high-level student himself who is at such a level that he deserves to be a recipient of a fellowship rather than give it to the university who might then not be able to convince him to teach? In your statement, you talked about being engaged in research to the extent where you never used the same lecture notes twice. I would expect that this would be the most stimulating kind of activity around which the student could be engaged. I think that inspiration of students is an important function of our research activity and that we should use our best people in the process of their research to be inspirations.

Dr. SEABORG. Yes. I think that research and teaching go together very well, and research and teaching in graduate education should be tied together at every possible opportunity.

Mr. DADDARIO. Mr. Davis.

Mr. DAVIS. Dr. Seaborg, there is a question that has bothered me for a long time that does not specifically pertain to the relations between NSF and AEC but nevertheless does pertain to both of you.

Some time ago I read an account of a gentleman who in the early days of wireless telegraphy, or radio transmission, succeeded in getting hold of quite a bit of money by giving lots of lectures and giving himself credit for a lot of things that he really was not entitled. He was almost an imposter, and more than once he committed virtually what amounted to larceny to the ideas of European scientists. Right now I have forgotten what his name is.

Dr. SEABORG. It's probably just as well that you fail to recall his name.

Mr. DAVIS. I agree with you. You never hear the breath of suspicion on the part of anybody that all of our Government money for basic research and development isn't being well spent and isn't being put in the most capable hands. I would like to have your comment as to whether or not there is a possibility that we are misspending some of our Government money. Are you satisfied that all of our money so far as you know is being well spent?

Dr. SEABORG. I think the overwhelming proportion of it is being well spent, but I am sure that some mistakes are made. I think that this is caught in the review procedure when the grants or contracts come up for renewal, at least the large proportion of such cases are discovered in the review procedure.

Mr. DAVIS. Do you refer there to duplication or just an error?

Dr. SEABORG. I was referring specifically to your question of whether some of it might be misspent, and I had in mind less than adequate quality of research results. As to duplication, I don't consider that to be a very serious problem. That is taken care of by the nature of science, in the publication procedure, and so forth. Good scientists cannot afford to duplicate unnecessarily the work of other good scientists. Some checking of results, of course, is necessary, and I would not regard that as duplication in the sense that the term would be used here.

Mr. DADDARIO. You have spelled out the joint efforts you have with NSF, NIH, and others which I imagine are directed toward this objective as well?

Dr. SEABORG. Yes, toward both objectives: toward eliminating the low-grade work, the less-than-adequate research work, and eliminating the undesirable duplication.

Mr. DAVIS. There is one other question I had, and that refers to the Science Information Exchange which you refer to on page 9 of your statement. Just how large a group does that exchange serve? How many agencies feed information into it or receive information from it?

Dr. SEABORG. The Science Information Exchange that I refer to is operated by the Smithsonian Institution, and this collects information on the research in progress under Federal support by all departments.

Mr. DAVIS. Does it try to handle the entire spectrum of scientific work?

Dr. SEABORG. It handles the physical and life sciences.

Mr. DAVIS. Isn't there a private company, Documentation, Inc., which does the same sort of thing?

Dr. SEABORG. Yes. I think that company does it for NASA.

Mr. DAVIS. I was not aware that it was restricted to NASA, but I know it does serve NASA.

Dr. SEABORG. I don't know either, whether it is restricted to NASA or not.

Dr. VANDERRYN. They are a contractor to NASA I believe. We contribute our basic research information to the Science Information Exchange.

Mr. DAVIS. Has your experience with Science Information Exchange been good? For example, suppose you were going to assign a given task to some university, and you first wanted to screen it through Science Information Exchange to see if it had already been done or if it were in progress at some other university, do you use SIE for that purpose?

Dr. SEABORG. Yes, we do. We also have liaison through a member of our staff on the board.

Mr. DAVIS. Has it been successful?

Dr. SEABORG. We think it has been quite successful.

Mr. DAVIS. I have heard it said in testimony before this committee that it is quite often true that when you go to code a description of some particular task, that quite often the title will be about as long as the description. If you want to pinpoint what some particular worker is doing, it is a very difficult thing to do. If this is true, I thought that perhaps your experience might have been less than satisfactory.

Dr. SEABORG. No. It is difficult to describe briefly in the title—the content of a scientific research program in such a way that it can be readily retrieved through a computer system or equipment of that type, but I think that SIE is doing a good job. There is, of course, a continuous attempt there to improve the information retrieval system.

Mr. DAVIS. It is true, too, is it not, that the men engaged in that particular field of inquiry stay in close touch with each other?

Dr. SEABORG. Oh, yes, they do that by exchange of their own papers, preprints and reprints of their published work, and by correspondence, and at scientific meetings, in symposia, and in cases of a particularly exciting result, by telephone.

Mr. DAVIS. I notice that AEC and NSF both put on many institutes and symposia, which I believe to be a good thing.

Dr. SEABORG. Yes. I think this is one of the best means of exchanging information—scientific information.

Mr. DAVIS. Then you do not have to rely entirely on SIE to prevent against duplication?

Dr. SEABORG. No.

Mr. DAVIS. You have many human contacts.

Dr. SEABORG. Oh, yes. And there are lots of other areas of scientific results, nongovernmental and broadly in the universities, internationally in other countries, and so forth that are handled by abstracting services of which there are quite a number. The chemical abstracts of course, of the American Chemical Society is one of the chief such services; the physics abstracts partially supported by the Ameri-

can Institute of Physics; the Nuclear Science Abstracts which the Atomic Energy Commission itself prepares and publishes, and many other abstracting services play a very important role in this connection.

Mr. DAVIS. Thank you. That is all.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Dr. Seaborg, I would like to thank you for your emphasis on coordination. I think most of us realize this must be a serious problem in the data collection field. As I understand it, coordination is achieved both through these formal panels and through the informal interagency groups that you mentioned. Do you sometimes have what we might call jurisdictional disputes that you cannot solve, and do you ever appeal to the President's Scientific Adviser for decisions? In other words, how do you resolve matters of interest to both agencies which may result in duplication?

Dr. SEABORG. Well, I think that in the case of our relationships with NSF we have been able to resolve any differences ourselves. I can't remember any unresolved differences.

Mr. CONABLE. You cannot remember having had to appeal to a higher authority? One of the functions of the President's science adviser is to coordinate agency program. This function, you will remember, was taken away from the National Science Foundation.

Dr. SEABORG. I think in such an instance we would use the science adviser, the Office of Science and Technology, or the Federal Council for Science and Technology, if it were a matter of some inportance.

Mr. CONABLE. Has it been possible to reduce any duplication simply through these informal procedures and through constant contact?

Dr. SEABORG. Yes. I do not recall any instances where there has been dispute with the NSF.

Mr. CONABLE. Which is the more important contact, the informal interagency groups or the panels?

Dr. SEABORG. I would imagine the informal day-to-day telephonic contact probably does more work than anything else.

Mr. CONABLE. There have not been any unresolved problems that you know of under this procedure?

Dr. SEABORG. No, sir. None of any consequence have come to my attention, and I am certain they would have if there had been any problems of any consequence.

Mr. CONABLE. Thank you. That is all, Mr. Chairman.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Dr. Seaborg, there was not too much said in your prepared remarks with regard to support of either international science research or information dissemination. The AEC does have programs in these areas, does it not, as well as the NSF?

Dr. SEABORG. Yes. You mean the support of scientific research?

Mr. BROWN. I mentioned both things, the support of scientific research in other countries and the exchange of information through translation and other types of services.

Dr. SEABORG. Yes, we do. We have some support of research in other countries, I guess more particularly in the area of biology and medicine and nuclear power reactor development. That is, in the area of the peaceful uses of atomic energy. We have exchange of information through agreements—special agreements and bilateral agreements—with a large number of countries, 30 or 40 countries, in

the field of the peaceful uses of atomic energy. Then, as I indicated, we have a rather substantial science information program of our own of which the Nuclear Science Abstracts is a good example. These are abstracts of work in nuclear science from all over the world, from all countries where such work is being conducted. We have a program for the preparation of monographs and a program of support for attendance of scientists at international meetings, just to mention a few of the areas in which we cooperate.

Mr. BROWN. Is there an underlying policy which governs our actions as far as support of nuclear scientific research in other areas that could be expressed relatively simply?

Dr. SEABORG. Well, it is basically that we support such work when it can be done better there than anywhere else.

Mr. BROWN. You made one brief reference on page 2 to a description of how breakthroughs occur and how the AEC would begin to support them when it became obvious that they are of concern to the nuclear program. You mentioned superconductivity and its use in controlled thermonuclear research. While this question is not particularly relevant to relationships between AEC and NSF, I have noticed in one of the AEC's own publications that our expenditures in the field of controlled thermonuclear research have been gradually increasing over the past 4 or 5 years but that the Russian expenditures have been increasing at an even faster rate. To what degree are we conversant with the work that Russians are doing? Why do they find more opportunities in this field to spend money than we do? Why are their expenditures 50 percent more than ours?

Dr. SEABORG. We are quite conversant with their work in this field. Under the exchange agreement, the Agreement for Cooperation in the Peaceful Uses of Atomic Energy, which was signed by Chairman Petrosyants of the State Committee of the U.S.S.R. on the Utilization of Atomic Energy and myself in May of 1963, we have had a number of exchanges and particularly exchanges of teams—an American team went to the Soviet Union and a Soviet team visited us in the United States to look at the work in controlled fusion reactions.

Mr. BROWN. That is what I was referring to specifically.

Dr. SEABORG. Specifically, we have had exchanges of teams between the United States and the Soviet Union in the field of controlled fusion reactions. With respect to whether we could think of a broader program than we now have, I would say that our scientists certainly could do that. I think they feel that they are a little bit under wraps due to the perennial problem of budget limitations. Our program effort has remained essentially level in the past 4 or 5 years. We are having a review of our program by a high level panel, which we would hope would be able to report recommendations as to the future of our program before the end of the year. This panel is under the chairmanship of Prof. S. K. Allison of the University of Chicago. So, I would say we are in a sense at a sort of crossroads in our controlled-fusion program and may recommend different directions and possibly an expansion of the program when we receive the report of that special review panel.

Mr. BROWN. It just seems to me if we had known 10 years ago the extent to which the Russians were doing work in the satellite field it might have modified our policies a little bit at that time, and here

we seem to be aware of the fact that they are devoting an unusual amount of effort to a field that could have rather important implications.

Dr. SEABORG. Yes, although there are some differences. It is a long-range program; it is a program in which the results of the investigations are published and we think will be generally available.

This is a very important area of investigation. The goal of being able to literally burn the heavy hydrogen in the water of the oceans to produce energy is a very important one. But the problems of containing the material and of reaching the very high temperatures that are required are so great that it is likely that we won't be able to solve the problem to the extent of obtaining practical large amounts of energy from the fusion reaction before the end of this century. So, the problem doesn't have the immediate urgency of the space program, but the failure of this Nation to keep sufficiently knowledgeable in the field of high-temperature plasmas would be undersirable.

Mr. BROWN. If we spent twice as much money, could we do it twice as fast between now and the end of the century?

Dr. SEABORG. No; I do not think we could. But I think we could usefully spend more money than we are, in shortening the time. It would be difficult to predict how much it would shorten the time.

Mr. BROWN. That is all, Mr. Chairman.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I would like to ask a question or two of Dr. Seaborg.

Do the breeder reactors, such as the Enrico Fermi reactor, promise an early solution to the provision of much increased power, or not? How significant is this role compared to that, for example, of hydrogen fusion?

Dr. SEABORG. Oh, the breeder reactor will play an important role in producing power in our country and throughout the world, I think, before hydrogen fusion will do so. Specifically, the breeder reactor will play not only an important but an essential role in producing electrical energy in the future. We have a program in the United States under the auspices of the Atomic Energy Commission whereby we are giving increasing attention to the advanced reactors that use nuclear fuel, fertile material such as uranium and thorium, more efficiently.

We are developing first what we call advanced converter reactors which produce nearly as much fuel as they consume while they are producing electricity. Somewhat concurrently, but a little later so far as the final goal is concerned, we are developing breeder reactors which produce more fissionable material than they consume in the process of developing electricity. These types of reactors are absolutely essential because if we continue to use up our uranium and thorium with the present water-cooled reactors, which seem to be on the verge of being economically competitive but which do not use the nuclear fuel very efficiently, we would find that nuclear fission was not contributing to our long-range energy needs as much as nuclear fission should or as much as nuclear fission can and must do in the future. So, the development of the breeder reactor, as an important part of our program, is coming along quite well, and the time scale is approximately such that in the 1980's we should have rather large breeder reactors which are producing electricity and additional fuel in the process of producing electricity to be used for fueling other reactors.

Mr. VIVIAN. Have any requests for funding for such research and development been denied by the Congress?

Dr. SEABORG. I would not say that there has been no request for funding denied by the Congress, but I do think that the funding for the development of breeder reactors that has been provided by Congress is at a pretty reasonable rate.

Mr. VIVIAN. Have there been any significant deletions at the Bureau of the Budget level?

Dr. SEABORG. I think that there have been deletions in detail at the Bureau of the Budget level, but again I think that the overall level of support has been quite good. We are at the present time, as I indicated, giving our greatest attention in terms of funding to these advanced converter reactors, and we have two of these in the fiscal 1966 budget and another one that we look forward to funding in an early subsequent year.

Mr. VIVIAN. I would like to switch to another subject. In terms of the history of funding for research and development within the Atomic Energy Commission, how has research and development funding fared over the past 10 years as compared to the production or utilization of nuclear materials or explosives? How has the R. & D. sector fared?

Dr. SEABORG. Quite well. The research and development, and in fact the whole area of the peaceful uses of atomic energy has been steadily increasing. Due to the fact that the need for fissionable materials for nuclear weapons seems to be more than adequately met, the budget for the production of fissionable materials and the production of nuclear weapons from fissionable materials has been reduced, more especially in recent years.

An example might be our budget for the current fiscal year, for fiscal 1966. There was an increase in the budget for all aspects of the peaceful uses of atomic energy and a decrease in the budget for the purchase of raw material, uranium, for the production of fissionable materials and for the fabrication of weapons from fissionable materials. I think I could put this in some perspective by indicating the extent of this decrease. Three years ago about 70 to 75 percent of the budget of the Atomic Energy Commission was concerned with these aspects of the production of nuclear weapons. In fiscal 1966 the budget of the Atomic Energy Commission is divided about equally between the peaceful uses of nuclear energy and all aspects of the production of nuclear weapons.

Mr. VIVIAN. I would like to switch to a question of manpower. I have had a fair number of persons who have been in my own personal employ in times past who were trained in nuclear physics, typically in either theoretical or experimental nuclear physics, and who drifted out of that field almost as soon as they obtained a Ph. D. I had the impression that that is quite a widespread phenomenon. I am not quite sure that is undesirable at all in that I think this training is an excellent background. I would rather see more of this than less. Is this a typical situation in your view? Are there a larger number of people trained in advanced and theoretical nuclear physics than are used by the nuclear industry, I don't mean industry itself, but the entire collection of users, governmental and nongovernmental?

Dr. SEABORG. There are a large number of the graduates in nuclear physics that are used by industry and by the universities, but, as you

say, there are an appreciable number that go into other fields. I believe there are some who are even trained in other fields that go into the nuclear industry. I think this is a good thing, and I don't believe that there is anything about the situation at all that alarms me.

Mr. VIVIAN. I notice you have evaluation by peers mentioned in your remarks, and you refer to the fact that most programs are evaluated by three or more persons in the field. Would you say this affects 50 percent, or greater, of the amount of money awarded under the various grants and contracts?

Dr. SEABORG. Oh, yes. I think that in the area of support for basic research in the universities this procedure is used essentially 100 percent of the time.

Mr. VIVIAN. And the exceptions, then, would lie in the contracts to industry or——

Dr. SEABORG. The reason I put it that way is we have a substantial part of our support for research covering the work in our own large multipurpose national laboratories.

Mr. VIVIAN. A final question, do you have any comments on the subject of geographical distribution of the funds utilized for atomic energy? Is it concentrated in any particular areas historically or at the present time?

Dr. SEABORG. I think that in the area of our support for research in universities through our contracts it is quite widespread. We have something of the other of 500 contracts in the Division of Research and about the same in the Division of Biology and Medicine. We have made analyses of the spread of these throughout the country which indicate that there is quite a broad spread there, and perhaps they would be worth submitting for the record if you would like to have them.

(The information referred to is as follows:)

AEC fiscal year 1964 R. & D. operating costs and related education and training activities (excludes costs incurred in foreign countries)

By Bureau of Census Divisions	Amount (in thousands)	Percent
Recapitulation:		
New England	$55,240	4.5
Mid Atlantic	192,705	15.6
East North Central	109,467	8.8
West North Central	10,673	0.9
South Atlantic	32,749	2.6
East South Central	81,934	6.6
West South Central	6,435	0.5
Mountain	397,458	32.1
Pacific	351,954	28.4
Total	1,238,615	100.0
New England:		
Maine	271	
New Hampshire	70	
Vermont	46	
Massachusetts	22,179	
Rhode Island	566	
Connecticut	32,108	
Total	55,240	
Mid-Atlantic:		
New York	110,167	
New Jersey	13,740	
Pennsylvania	68,798	
Total	192,705	

AEC fiscal year 1964 R. & D. operating costs and related education and training activities (excludes costs incurred in foreign countries)—Continued

By Bureau of Census Divisions	Amount (in thousands)	Percent
East North Central:		
Ohio	$31,289	
Indiana	6,491	
Illinois	64,424	
Michigan	3,321	
Wisconsin	3,942	
Total	109,467	
West North Central:		
Minnesota	2,077	
Iowa	6,703	
Missouri	1,116	
North Dakota	21	
South Dakota	139	
Nebraska	123	
Kansas	494	
Total	10,673	
South Atlantic:		
Delaware	$76	
Maryland	7,838	
District of Columbia	5,021	
Virginia	3,921	
West Virginia	96	
North Carolina	1,402	
South Carolina	11,618	
Georgia	615	
Florida	2,162	
Total	32,749	
East South Central:		
Kentucky	167	
Tennessee	81,500	
Mississippi	70	
Alabama	197	
Total	81,934	
West South Central:		
Arkansas	392	
Louisiana	242	
Oklahoma	128	
Texas	5,673	
Total	6,435	
Mountain:		
Montana	23	
Idaho	32,709	
Wyoming	13	
Colorado	1,531	
New Mexico	237,613	
Arizona	3,108	
Utah	865	
Nevada	121,596	
Total	397,458	
Pacific:		
Washington	34,600	
Oregon	785	
California	294,609	
Alaska	63	
Hawaii	21,897	
Total	351,954	
Grand total	1,238,615	

Mr. VIVIAN. I would appreciate receiving it. Does that also pertain to your major governmental centers?

Dr. SEABORG. Our major governmental centers, or so-called multipurpose laboratories, or national laboratories, sprang up in large

part during the war under conditions where such criteria as isolation often were important. The net result has been that we have a rather good spread in the geographic location of these laboratories, as you probably know. We have one of the major ones in the South at Oak Ridge, Tenn., and another laboratory connected with one of our production centers in South Carolina, the Savannah River Laboratory; we have the Pacific Northwest Laboratory in the southeastern part of the State of Washington; and, of course, we have the Los Alamos Scientific Laboratory in New Mexico; and, in addition, laboratories on the east and west coasts, the Brookhaven National Laboratory on Long Island, N.Y., and the Lawrence Radiation Laboratory in Berkeley and Livermore, Calif.; and the Argonne National Laboratory in Chicago. There are other laboratories as well, but all and all I think the geographic spread is, although it may be said to have resulted somewhat accidentally, quite good.

Mr. BROWN. You don't have any in Texas, do you?

Dr. SEABORG. We don't have any of these national multipurpose type laboratories in Texas; no, sir.

Mr. DADDARIO. Dr. Seaborg, I have a whole series of questions which I hope to send to you for answers.[1] However, I would like to ask you one question now.

You have indicated that when mission-oriented agencies have difficulty in doing the required share of basic research, that the National Science Foundation should fill in the gap and play an increasing role. Have you given any thought to the type of growth that this would indicate, for example, percentage figures related to budget increases?

Dr. SEABORG. I think it would require something of the order of a 15-percent increase per year just to continue about the same degree of support as at present. There is about a 10-percent increase in the numbers of researchers in the universities and colleges annually and about a 5-percent increase in the cost of doing research, so that just in order to maintain the same degree of support requires an increase of about 15 percent per year.

Mr. DADDARIO. As you review the record, if you would like to enlarge upon that answer, please feel free to do so.

I want to thank you for your testimony, Dr. Seaborg, it has been most excellent. This committee will now adjourn to the same place tomorrow morning at 10 o'clock.

(Whereupon, at 12:22 p.m., the meeting was adjourned to reconvene at 10 a.m., Wednesday, July 7, 1965.)

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

WEDNESDAY, JULY 7, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Our first witness this morning is an old friend of this committee, the Deputy Administrator of the National Aeronautics and Space Administration, Dr. Hugh Dryden.

Dr. Dryden, we are pleased to have you with us, as always, and we look forward to your testimony.

STATEMENT OF DR. HUGH L. DRYDEN, DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY DR. HOMER E. NEWELL, ASSOCIATE ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. DRYDEN. Thank you, Mr. Chairman and members of the subcommittee.

It is indeed a pleasure to appear before you this morning in connection with the comprehensive review that your subcommittee is making of the National Science Foundation. The National Aeronautics and Space Administration, as did its predecessor agency, the National Advisory Committee for Aeronautics, has had a long and satisfactory experience in its relationships with the National Science Foundation.

As a matter of fact, it was Dr. Vannevar Bush, in his report "Science, the Endless Frontier," who set forth the need for and suggestions that ultimately led to the creation of the National Science Foundation. He not only saw this need from his work with the Office of Scientific Research and Development during World War II and from his long years of association with the National Advisory Committee for Aeronautics from 1938 to 1948, but conceived the manner in which the Federal Government might meet it.

In the 15 years since the signing of the National Science Foundation Act by the President on May 10, 1950, the National Science Foundation has made an increasingly important contribution in promoting the progress of science in this country.

In carrying out its fundamental purpose of strengthening the basic research and education in the sciences in the United States, the National Science Foundation is engaged in a wide variety of scientific activity. It is concerned with the development and dissemination of information relating to scientific resources, including manpower, aimed at facilitating national decisions relating to strengthening the scientific effort of the Nation. It is engaged in the award of grants and contracts primarily to universities and other nonprofit institutions in support of basic scientific research, for research equipment, for the construction of laboratories of specialized facilities, and for generally strengthening an institution's scientific endeavors.

The latter is typified by the recently initiated Scientific Development Program. It supports national centers, such as the Kitt Peak National Observatory, where large facilities are made available for the use of qualified scientists. It awards graduate fellowships in science. It supports a wide variety of programs aimed at improving scientific education in the United States. Finally, it is intimately involved in the problems of scientific information acquisition, collation, and dissemination.

The National Aeronautics and Space Administration's program, which is seeking to expand human knowledge of the phenomena in the atmosphere and space, is the most comprehensive and complex scientific and engineering effort ever undertaken by man. In it is included extraordinary contributions in basic research. To the casual observer, the question which immediately arises is, Why should more than one group be engaged in carrying out basic research? The answer is a complex one; but to put it in the simplest terms, basic research is essential in any scientific and engineering endeavor. Thus any national program, such as the space program, the atomic energy program, our defense program, must carry out basic research in support of its mission. It may even be said in like sense that the National Science Foundation also has a mission. But its mission is a broad one covering all science as opposed to the more limited interest of the so-called mission-oriented agencies.

In carrying out its activities, NASA draws heavily on the results achieved in the promotion of progress in science by the National Science Foundation. To have a strong NASA, a strong AEC, or any strong new national scientific program that may arise in the future requires that this Nation maintain a strong National Science Foundation.

This strength, however, must be planned in the light of the scientific activities of the various Federal agencies as well as the scientific activities of the private sector of our country. The NSF must strive to develop a program that strengthens all of the science with particular attention being given to those areas that lie between the strong thrusts that are made by the mission-oriented agencies in the areas of direct concern to them.

The concept of plurality of Federal research support is one that has been accepted and endorsed by all branches of the Federal Government and by the academic community. In the case of my agency, the National Aeronautics and Space Administration, to be strong and viable requires a direct and intimate relationship with all segments of the scientific and industrial community that form the Gov-

ernment, university, and industrial team essential to the conduct of the space program. The problem of concern is not, nor should it be, one of a single agency supporting all research, but rather how the total activity is coordinated to assure that a wise total program is being pursued.

In this regard I would like to spend a little time discussing several activities of NASA that are intimately related with activities of the National Science Foundation to show how our activities are coordinated and how we work together for the national interest.

The first I would like to discuss is that of support of basic research. I have chosen to discuss the area of astronomy because is in reality the Nation's first space program. Further, the report prepared and issued in the latter part of the 1964, "Ground-Based Astronomy—A 10-Year Program"—the Whitford report—by a panel on astronomical facilities of the National Academy of Science's Committee on Science and Public Policy, provides the basis for comparing the role of the Foundation and the role of NASA in this field.

Astronomy is an area which illustrates the way in which NASA and NSF have shared the responsibility for maintaining this Nation in the forefront of astronomical research. I would like to review the kinds of support which each agency provides, how we coordinate our support, and why I feel a strong Foundation will strengthen the NASA program.

Prior to the establishment of NASA in 1958 the National Science Foundation was the single agency responsible for the overall support of astronomy. The establishment of NASA with a charter to expand human knowledge of space phenomena raised a question as to the role of the astronomer in space research. It was clear that the ability to observe astronomical objects outside the obscuring effects of the atmosphere would advance the science of astronomy by an amount comparable to the invention of the telescope itself. It was equally clear that orbiting a telescope and pointing it with the required accuracy would be one of the most complex and difficult tasks of the space program.

If, at that time, we had had to evolve a program of space astronomy while simultaneously training new astronomers it would have been many years before we could have even begun the development of our orbiting astronomical observatories. Fortunately, we did not have to wait, because there existed competent astronomers who had long recognized the potential of space astronomy, who had well-thought-out programs, and who were ready to exploit the opportunities provided by space flight. These astronomers existed because this country possessed the wisdom and foresight to provide, with public and (particularly in the case of astronomy) private funds the facilities to enable people with ability and interest in astronomy to train themselves to conduct research in astronomy.

It is imperative, particularly as the cost of research increases and the ability of institutions to obtain sufficient private support decreases, that the National Government adequately provide for the support of basic research in all the broad scientific disciplines, such as astronomy. How do we coordinate the NASA program in astronomy with the National Science Foundation support of the broad basic research in all of astronomy? As a result of the Whitford

report, recommending increased support of ground-based astronomy, we in NASA recently made a detailed reexamination of our policy in the support of astronomy. The National Science Foundation was requested by the Office of Science and Technology to assemble an ad hoc group of agency representatives to make a Government-wide assessment of the Whitford report.

I would like to quote two passages from the documents which NASA transmitted to the National Science Foundation as a part of our assessment of the Whitford report. These passages summarize our policy on the support of astronomy and the important role which we feel NSF must play:

> General support of astronomy in the province of the National Science Foundation: NASA cooperates with this and other Government agencies in an attempt to insure support of deserving programs and to discourage any possible attempt to stimulate competition between agencies. However, it is obvious that the exploration of space must intimately involve both astronomers and astronomical research. It is difficult to conceive of any area of astronomical research which has no contact with space exploration. Moreover, in many areas of its program, NASA urgently needs additional astronomical research both to plan its programs intelligently and to interpret the results obtained. Therefore, NASA has undertaken the support of both astronomical research and astronomical facilities in those areas of astronomy which most directly affect the space program. In addition, it has used the flexibility of its supporting research and technology program, its field center research, its training grants, and its facilities grants to support, at a lower level, an important broader base of astronomical research from which more closely mission-oriented research must arise.
>
> We recognize the close connection between ground-based astronomy and the exploration of space; however, we feel that the broad general support of ground-based astronomy should continue to be the responsibility of the NSF. NASA has in the past supported certain ground-based facilities and will continue to do so in the future after coordination with other Government agencies to avoid duplication. The NASA funds available for the support of ground-based astronomy can support only a fraction of those new ground-based facilities which do one or more of the following:
>
> 1. Contribute directly to understanding the results from the space program.
> 2. Assist in the conception, design, development, and testing of instruments and spacecraft,
> 3. Perform the exploratory and basic research necessary to guide the planning and evaluation of scientific missions and experiments in space.

I would like to interpolate a little more specifically. As you know, our original exploration of space will certainly be, as far as direct exploration, confined for some time to the solar system and particularly to the Sun, the Moon, the planets, and in the early stages to Mars and Venus. It is quite obvious, therefore, that the Space agency has a special interest in the astronomy of the planets, a subject which has engaged the interest of a few astronomers, but has not been a sufficiently popular subject to attract a large number of people. We have, therefore, felt it necessary to stimulate increased interest in the astronomy of the planets.

In the second place, the astronomical observatories enable the observation of the stars outside the Earth's atmosphere, and in order to make astronomical measurements of the wavelengths which do not get through the atmosphere, the extreme ultraviolet and so on, it is necessary for us to support considerable development of instrumentation in those areas which are not ordinarily done in connection with ground-based astronomy.

I think these two specific illustrations may make the general statement a little more intelligible.

In summary, the area of astronomy, certainly a fundamental scientific discipline, illustrates the need for both broad support on all the frontiers of astronomy by NSF, and support of specific areas of astronomy by NASA in order to accomplish its mission.

I would like to turn now to another realm of mutual interest to NASA and NSF, that of graduate training. This also is an area that I believe is of considerable interest to your committee because of the educational problems facing the Nation. NASA has had a strong feeling or responsibility to assure the availability of highly trained scientists and engineers required for the successful conduct of the space program.

As you are well aware, the space program has been a very active and dynamic program since its inception in 1958. This program was born at the time this country was facing a shortage of highly trained scientific and technological personnel and grew quite rapidly. While our present demands and future requirements involve only about 5 percent of the Nation's scientific and technological manpower pool, it was readily evident that in this new field of endeavor it was in the national interest to take immediate steps to increase the production of Ph. D.'s. One of the significant findings in this regard was the report of the Gilliland Committee of the President's Science Advisory Committee which called for doubling the production of Ph. D.'s by 1970. In view of the fact that NASA's appropriation amounted to about one-quarter of the Federal R. & D. dollars, it took as its goal the production of 1,000 Ph. D.'s annually, which represents approximately one-quarter of the increase which is generally considered to be desirable.

Benefiting by the experience of the National Science Foundation, the National Institutes of Health, and the Office of Education in their predoctoral programs, NASA developed and initiated its predoctoral training grant program in fiscal year 1962. This program is now nearing the planned level—the entrance of 1,350 new students annually into the program. It is hoped that with normal attrition, approximately 1,000 of these students will receive their Ph. D. by the time they have completed the 3 years they may be supported in the program.

This program was developed around the basic policy that NASA has for all its activities with the Nation's universities; namely, that of working within the structure of the university in a manner that will not only make it possible for NASA to accomplish its mission, but that will also strengthen the university. Time does not permit an elaboration of all of the details of this program, other than to state that grants are made to universities who in turn select the students. In addition to stipends for the students funds are made available to the university to help defray the cost of the program to the university. However, these funds are not specifically tied to the students but rather are made available to the university with the stipulation that they be used to enhance graduate education in space science and technology. That this has been a most successful program is evident by its acceptance by the universities and by the fact that it has become the model for other Federal fellowship programs.

The question has often been raised why it is necessary for NASA to have a predoctoral training program. Why can't all the Federal fellowship programs be handled by a single agency? I have already noted that NASA feels a responsibility to help develop the highly

trained scientific and technological personnel that will be required if the program is to be a success. But even more important than this is the interaction that is so essential in scientific programs between the academic community and the scientific people in the government charged with carrying on such programs. This direct interaction provides a mutual stimulation and permits the academic community to be more directly responsive to national interests.

While the selection of the students and the administration of this program is largely the responsibility of the universities themselves, the knowledge that the funds for this activity came directly from NASA, rather than from some interested but not directly concerned party, accounts in large measure for the fact that the subject matter of students theses and dissertations is a direct interest in the space program. Some examples are: "The Production of Tritium and Helium 3 by Proton Bombardment of Metals"; "Solar Origin of Terrestrial Tritium"; "Integration and Optimization of Sustained Thrust Rocket Orbits"; "Galaxy Formation in a Steady State Universe"; "Recombination Spectra of Hydrogen and Helium in Gaseous Nebulae"; to mention only a few. In addition, a number of technical publications by NASA supported trainees on space related subjects have already appeared in the scientific journals.

This program is still in its infancy inasmuch as the initial grants which covered only 100 students are just being completed. We have been extremely gratified by the results to date. As of June 15 we have been notified that Ph. D.'s had been awarded to 68 students. Of these students, information is available as to the initial career choice of 58 of them—I should mention that NASA does not require them to join NASA or to engage in any specific branch of science, other than that it be relevant to the space program—44 have chosen to remain with the university, 33 in research and teaching and 11 on postdoctoral appointments or Fulbright fellowships. Of the remaining 14, 2 were entering employment in Government laboratories and 12 were engaged by industry.

We feel that the fact that 75 percent of these were still within the university attests to the quality of the students participating in the program; furthermore these new Ph. D's are serving to meet an urgent national need by remaining in the university to help in the training of additional scientists and engineers.

While NASA subscribes to the plural system of support, we also are cognizant of the need for interagency coordination and cooperation. I would like to describe the manner in which the program I have just mentioned has been coordinated. First, Mr. Webb and I have had a continuing series of meetings with Dr. Seaborg, Chairman of the Atomic Energy Commission, with Dr. Alan Waterman, and more recently with Dr. Leland Haworth, Director of the National Science Foundation, and with Mr. Keppel, Commissioner of Education. In addition, there have been discussions on areas of mutual interest between Dr. Newell, Associate Administrator for Space Science and Applications and Dr. Smull, Director of our Office of Grants and Research Contracts, with Drs. Spofford English, Paul McDaniels, and C. L. Dunham of the Atomic Energy Commission and Drs. Bowen Dees and Howard Page of the National Science Foundation.

Further, there is an ad hoc interagency group called the Federal Fellowship Administrators that meets regularly to exchange ideas and information on such programs. Dr. Thomas Fontaine of the NSF has taken the leadership in getting the group together, which includes representatives not only of the National Science Foundation, the National Institutes of Health, Office of Education, Atomic Energy Commission, Department of the Interior, State Department, Department of Defense, Department of Agriculture, Smithsonian Institution, and NASA. Dr. Frank Hansing who handles NASA training programs has regularly participated in this activity.

In addition, by Executive order the President recently established the Federal Interagency Committee on Education which is chaired by Mr. Keppel, Commissioner of Education, and has representatives of the interested government agencies.

Finally, there are numerous almost daily contacts among our respective staffs at the operating level.

I have gone to some length in discussing the NASA training grant program, not particularly from the standpoint of the program itself, but rather to give you a picture of the types of things that are important to NASA and also of direct interest to the National Science Foundation. Of particular importance is the manner in which we coordinate such activities. If one were to consider the support of research in the academic community by NASA or the provision of research facilities by NASA in detail, he would find that the same type of interagency coordination and cooperation was being carried on in these programs also.

To give you an example of how mission-oriented agencies—in this case, NASA—and the National Science Foundation can work together, I would like to call your attention to the joint action taken recently by NASA and the NSF in making grants to the University of Minnesota, to permit the university to strengthen its scientific and technological capability. Prior to this joint action, there had been a substantial involvement by the University of Minnesota in the space program under NASA support, and in general scientific research supported by NSF. The combined NSF/NASA action included a grant from NASA for approximately $2.5 million for the construction of a building to house the university's space science center and a grant for the support of multidisciplinary research in space science and technology.

An integral piece of equipment, important not only to the research in space science and technology, but also to the scientific programs throughout the university was a computing facility for which the Science Foundation made available to the university approximately $400,000. The announcement noted that this:

> Joint action by NASA and NSF was undertaken to encourage the development of space science and technology, to help strengthen the university in both research and the production of creative manpower, and to stimulate a strong and continuing interaction between the university and the industrial community in the region which it serves.

As it has in the past, the Federal Government must continue to recognize the individual nature of our universities. It is this individuality on the part of the university that is the very basis of their

strength and must be dealt with accordingly. Although the pattern will vary from case to case, I think this type of cooperative action that I mentioned is one that you may expect to occur with increasing frequency in the future.

As noted in the beginning of my statement, NASA believes that mission-oriented scientific agencies such as itself and the Atomic Energy Commission can be most effective in the long run if there is a strong National Science Foundation. I would like to suggest that, while the Science Foundation has underway a variety of excellent programs that have been developed to achieve success in its mission—that of strengthening basic research and education in the sciences—there are two areas that at present are believed to merit special consideration.

The need for an adequate geographical distribution of our scientific endeavors, which has been discussed so much in the present Congress, is not new. The first annual report of the National Science Foundation which was submitted to the President on November 1, 1951, states:

The National Science Foundation proposes to support basic research on as broad a geographical and institutional bases as possible.

The intellectual activity and scientific competence that is to be found centered in the Nation's universities is daily of increasing importance to our national welfare. NASA, as well as the other scientific agencies, recognizes the need for a broad national basis to carry on a program that has national significance, as does the space program. The lead, however, in developing a broad base of scientific activity should aggressively be undertaken by the National Science Foundation. I feel that the mission oriented agencies must give prime consideration to the matter of competence. I believe we would all rest considerably less easy if we felt that any region of the country was barred from developing a good idea for a superior weapon system or a superior space vehicle because it had just provided the last one. That the Science Foundation is concerned with broadening our base of scientific competence is evident by the recent initiation of their science development program which is aimed at developing additional centers of excellence throughout the Nation. NSF should be encouraged in these efforts, since through the development of a broad strong base of scientific competence will come added strength to NASA, to the AEC, the Department of Defense, and to the Nation as a whole.

The second point I would like to make relates to the ever-growing importance of science in our way of living. Scientific endeavors can no longer be left in the hands of the few but rather must be in the conscious awareness of the many. While the National Science Foundation has educational programs that impinge at all levels of scientific instruction, the support of research and training has been concentrated at the graduate level. It is believed that the growing importance of science brings with it the necessity of increasing involvement on the part of the undergraduate. This is an area in which there is too little Federal activity at present. Because of the generality of the undergraduate's interest, it is believed that this is an area in which the National Science Foundation might well make a concerted effort.

Mr. DADDARIO. Do you carry this recommendation to the National Aeronautics and Space Administration, as well, that there be more aid in the undergraduate area?

Dr. DRYDEN. Generally, we have not gone in that direction at the present time, but we talk about it quite a lot and have talked in these meetings with Dr. Seaborg and Mr. Keppel and Dr. Haworth quite a lot.

Mr. DADDARIO. Do you see your mission prohibiting aid in this area, or do you see it as the peculiar function of the National Science Foundation?

Dr. DRYDEN. In general, you can't tell what an undergraduate is going to do later on, and for that reason broad support seems more appropriate.

However, I do not know of anything that would prohibit a program of this kind in NASA.

Mr. DADDARIO. Then your recommendation really goes beyond the National Science Foundation. You believe more can be done at the undergraduate level and it is just a question of how it can be worked out, rather than a specific recommendation that NSF be the only one that does it?

Dr. DRYDEN. Yes.

Finally, I would like to state that the National Science Foundation has, in the 15 short years of its existence, made a significant contribution to American science. Its continuing growth and dedication to strengthening basic research and education in the sciences is essential to our national welfare.

Now, Mr. Chairman, I am open to questions. Dr. Newell is with me. Certain subjects I might refer to him as better able to answer in detail. Between us, we will try to deal with the questions of the committee.

Mr. DADDARIO. We are happy to welcome Dr. Newell here, too, of course.

Mr. Mosher?

Mr. MOSHER. Dr. Dryden, on page 10 where you are discussing the Ph. D. program you say:

> It is hoped that with normal attrition, approximately 1,000 of these students which will receive—

And so forth. Has the attrition been normal, so far? I realize it is fairly brief experience, but is there any reason why this program should be less than normal or better than normal?

Dr. DRYDEN. I think we have had somewhat less attrition than is common in these programs, but I don't have these figures and we only have the experience with the first 100 at this time.

Mr. MOSHER. There is no reason to believe that it would be poorer than normal?

Dr. DRYDEN. I wouldn't think so. There is certain motivation about the space program that perhaps offsets some of the other attrition. I don't know.

Mr. MOSHER. Getting back to the point that Chairman Daddario was just asking, this concerted effort that the National Science Foundation might make at the undergraduate level, in what form do you think that might best be—assistance to individuals?

Dr. DRYDEN. No, we ourselves, as you know, pioneered in the policy of recognizing first that people usually don't go to college more than 100 miles away from home, there are a lot of good people in all parts of the country, that the administration is a lot simpler if you let the university pick its best people—it doesn't have to set up national committees, hold examinations. It knows from its own experience and its own record who the fine students are in that particular town, and we have rather preferred the system that we have worked out of having the universities select the best people, determine what fields they are going to award fellowships in, and so on. We think it might be a more effective program if it were handled in this way, rather than giving money to an individual who then chooses to go to one of the first 20 schools.

Mr. MOSHER. Which he probably would do.

Dr. DRYDEN. He would try to do. Not all of them would get in. Don't misunderstand me. I think the other type of program is a good one to have nationally, of recognizing bright students, but I don't think we ought to put all of our effort in that direction.

Mr. DADDARIO. I take it from your remarks that you recommend this program in balance with the others?

Dr. DRYDEN. That is correct.

Mr. DADDARIO. Mr. Roush?

Mr. ROUSH. Dr. Dryden, I want to express my appreciation for your statement that special consideration should be given to geographical distribution of our scientific endeavors. I would agree that the National Science Foundation should take the lead; I think they have taken the lead, although I believe in recent years there has been a tendency to pull the Foundation slightly away from their original admonition of Congress that consideration be given to geographical distribution. I would question and wonder about one of your statements, and that is the statement that you feel that the mission-oriented agencies must give prime consideration to the matter of competency. In the area of development and procurement——

Dr. DRYDEN. Yes, in the area of development and procurement.

Mr. ROUSH. I would agree with this part of it. In the area of research, I do not think this is as much a consideration.

Dr. DRYDEN. It is still an element of consideration, but it doesn't have the same degree of sharpness. If you have got to fly a rocket next month, you have got to find a fellow who can build a rocket.

Mr. ROUSH. In the area of basic research is it possible for a mission-oriented agency to pay a little more attention to the matter of geographic distribution?

Dr. DRYDEN. Yes, although still I think you gentlemen would be the first ones to criticize us if we put our money away on things that are obviously incompetent.

Mr. ROUSH. That is true.

Dr. DRYDEN. So competency is still a factor, but I agree with you that the relative weight, so to speak, of the various considerations that enter into the placing of contracts does not put this as high as it does in the development contract.

On the other hand, we don't want to support incompetent activities, either.

Mr. ROUSH. That is all, Mr. Chairman.

Mr. DADDARIO. Mr. Brown?

Mr. BROWN. I would just like to offer one line of thought here, Dr. Dryden. Your statement is replete with a description of science and scientific education and basic science and broad science and so forth. Yet it seems to me, as it has in many of the other statements, that basically you are referring to the physical sciences and engineering.

Dr. DRYDEN. It does not intend to, because the life sciences are also involved, although the principal agency in Government supporting the life sciences is the National Institutes of Health, of course.

Mr. BROWN. This is the point which I want to make clear—when we use the term "science" in these papers, that we are talking about physical science, life science, and social science; that science is not restricted.

Dr. DRYDEN. That is the intent; yes. We have some projects which would be called social science; very few, but some.

Mr. BROWN. I recognize in an agency such as NASA the opportunities to support social science may be somewhat limited. But when we are talking about an agency such as the National Science Foundation, which has a role in filling out the total pattern of science, we must consider these other things. We must secure proper balance for them, particularly where the mission-oriented agencies are devoted so strongly to particular areas.

Dr. DRYDEN. And I think there is such a thing as engineering science, although some of my friends think that is a contradiction in terms. But there is a variety of science called engineering science which is easily recognizable and distinguishable from technology.

Mr. BROWN. I am becoming more and more concerned that, with the proliferation of science, somewhere we become concerned with the way human beings can assimilate the results of science. Whether you call this concern a scientific concern or a social concern or a social science concern, I am not particular, but it is extremely important that we be able to make a proper connection between the ability of human beings to handle this knowledge and the generation of the knowledge itself.

Dr. DRYDEN. Nothing I have said is implied to indicate any lack of support for the humanistic side of life. I am very much interested in that personally. That doesn't happen to be the particular subject this morning.

Mr. BROWN. There is, of course, and I think should be, a strong interaction between the humanities and science.

For example, I think there is nothing more humanistic than knowledge of the broad field of astronomy. But as you indicate, NASA is not so much concerned with this aspect. However, I would like to have on the record wherever possible clarification that the National Science Foundation has a broader responsibility than purely physical science——

Dr. DRYDEN. I agree.

Mr. BROWN. And engineering, and that it may be extremely important that we move further in the direction of the social sciences, that is, the nonphysical sciences, in a broad sense.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. What are the mechanics of coordination in basic research between NASA and the National Science Foundation?

51-204—65—vol. 1——16

Dr. DRYDEN. Exchange of information on proposals submitted and the actions proposed.

Mr. CONABLE. Do you have a formal setup for doing this?

Dr. DRYDEN. It depends on what you call formal. We do exchange lists of proposals that are periodically assembled. When proposals come from a university, we like to know whether other agencies have received the same proposal and, if so, whether they are interested and what they propose to do with it. This is largely done by telephone and personal contacts, largely done by telephone, rather than what you might call a formal written procedure.

Mr. CONABLE. You don't have to formalize the arrangements?

Dr. DRYDEN. I think, as a matter of fact, the members are probably interested in one of the formal efforts to do this through the Science Information Exchange. NASA has cooperated in the provision of input concerning research and progress since the exchange was established. Figures compiled by the exchange indicate that NASA furnished information on 793 projects in 1963, 696 in 1964, and 338 in the first half of 1965. Under terms of our agreement with them we provide a complete list of research grants and contracts awarded.

With this information in hand the exchange queries the research investigators directly for specific information relating to work that they are planning to do. The recent agreement between NASA and the Department of Defense to more effectively exchange information on current research and technology programs has resulted in a standard reporting form by both agencies to facilitate machine processing, and I have seen these books in various fields which enable us to run down exactly what is going on in the other agency in any particular area. Dr. Bisplinghoff advised the exchange in April of this year that his office will expand the coverage of NASA-sponsored work in the information pool, but that recognition must be given to the fact that a sizable proportion is in a category which does not lend itself to dissemination for a general audience. That is a result of the NASA-DOD agreement to exchange information on research and technology programs. SIE will be provided information automatically in 1966, and during the interim period information will be reviewed manually in order to increase the coverage of NASA programs in the SIE files.

Mr. CONABLE. Does the initiative for the SIE come from the OST, or where does it come from?

Dr. DRYDEN. Originally I think it came from the Smithsonian Institution who then sought support from several agencies, and they did, I think, finally get the blessing of the Office of Science and Technology. For a while it was financed by contributions from about five or six agencies. More recently it has been included in the budget of the National Science Foundation.

Mr. CONABLE. The Office of Science and Technology is supposedly a coordinating group.

Dr. DRYDEN. They are not an operating coordinating agency in the sense that you are describing. They are policy. They fix the policies.

Mr. CONABLE. How do you generate cooperation between the agencies?

Dr. DRYDEN. Policies are discussed in several places; the Federal Council of Sciences and Technology, which is one of the agencies affiliated with the Office of Science and Technology, consisting of

Federal administrators, the President's Science Advisory Committee, consisting of outside people, and the Office of Science and Technology work on the policy formulation. They, for instance, as I say, took an action supporting the activities of the exchange in recommending that the National Science Foundation accept responsibility for its budget, in the interim providing for it by requesting several agencies to contribute, with the approval of the Bureau of the Budget.

Mr. CONABLE. I don't know whether I make myself clear. It seems to me in both talking with AEC and NASA, with respect to their relation with the National Science Foundation, that much of the discussion seems to involve picking up a phone and talking with somebody. This is fine, but how do you know somebody is doing that? Doesn't somebody oversee the whole thing?

Dr. DRYDEN. I don't know how to describe this. There are literally thousands of these respective proposals and there is no point in running these into a central point and having somebody who knows nothing about the field pass judgment. What you try to do is to have the various people at the operating level deal with the proposal. There is general oversight of the process by the Office of Science and Technology, and there are such activities as we have described of trying to obtain standard forms so that the information can be processed by a machine, and anybody involved would get a complete listing, which is indexed, by which he can look up the activities of an agency in any particular area.

Mr. CONABLE. You do not conceive that more operating coordination is necessary, then, than just the general oversight provided by OST and the cooperation that is generated within the various agencies on the same level?

Dr. DRYDEN. I don't see how to do this without multiplying a tremendous amount of paperwork which is of no value to anybody as far as I can see—daily, project by project, so and so telephoned this man and made this decision. Monthly we exchange lists of proposals that are before us; not actions completed, but things which have been proposed, so that if the proposal is on three desks it is known, and then those people get together and see who is interested in it. We don't want to get two people trying to support the same proposal.

Mr. CONABLE. That is all, Mr. Chairman.

Mr. DADDARIO. What you are saying is that even though there is no log kept, you know from experience that a great deal of communication goes back and forth. You are satisfied that this is the way to get the job done?

Dr. DRYDEN. Yes. I believe in the use of the telephone. It isn't always necessary to have large volumes of paper.

Mr. DADDARIO. We had testimony yesterday that this was probably the most fruitful exchange, the informal part of it.

Mr. Vivian?

Mr. VIVIAN. I would be glad to hold my questions if you would like to go on to the next witness.

Mr. DADDARIO. No, why don't you go on for 5 minutes or so?

Mr. VIVIAN. I would like to ask a question which I have asked of several other agencies. I am personally desirous of maintaining a multiple review of scientific proposals, among the agencies which are in a position legally to review and evaluate proposals, so that an in-

dividual submitting a proposal does not find himself running against the prejudice of an individual person.

Dr. DRYDEN. I think there is nothing worse than to have the decision made by one person.

Mr. VIVIAN. I am sure this is the view of a great many people in the scientific field.

Dr. DRYDEN. Yes.

Mr. VIVIAN. On the other hand, along with this opportunity runs a certain responsibility and that is to allow a split in the financial resources to each of these agencies along some pattern so that while there is a division of support, there is also a policy of splitting the funds. I am curious to know the areas in which you regard yourself as having overlap with the possible functions of NSF, which in your agency must be very great. What kind of policy establishes the split in funds; that is, what guidelines do you follow as to what should go to NASA and what should go to NSF?

Dr. DRYDEN. This is determined by the operative process of the executive branch and the Congress. This is the way it comes out.

Mr. VIVIAN. Congress has a certain degree of respect for the recommendations of the Bureau of the Budget, in some places more than others, and I am curious to know how this policy is established within your own operations. Do you make a recommendation, for example?

Dr. DRYDEN. We make a recommendation as to the amount of money in specific general fields that we think is required for supporting research and technology in connection with our mission. We do not feel we have a mission primarily to support universities. We have a job to do, and there are certain areas that are necessary to our job. In materiels, we just don't support materiels research. We want materiels included in rocket case. This fixes a certain general area.

I think a research man can be free in his research while working in a general field. There is no conflict. This is directed in a fashion in the sense that the mission agencies say, "We want you to work," or "We want people who are interested in working with tungsten, or molybdenum, to make us proposals," and if they fit in with the job we have to do, we try to give them support. I don't think we have any funds allotted—in fact, most of our funds are in the pocket of a program manager who has a job to get done, and it is his decision whether he gets the job done in industry or whether the nature of the job is one that he can take to a university, and certainly one of the things that we avoid is trying to put up a request for proposals to be bid on by university and industry. This doesn't make any sense to us, at all. Now, in general, our university proposals are unsolicited proposals. They are not requests from us to bid on anything. We want people who are interested in a certain field that they think is of interest to us, and we do give certain guidelines as to the kinds of areas that we are concerned with, to come to us with proposals. Then the program manager in this particular area decides whether this is a thing which helps him get his job done. This is the rationale behind any mission-supported agency. We want to carry out the mission in such a way that it strengthens the institutions with whom we deal. We would like to get this research done in such a way that it fits in then with the motivation and the practice of universities.

Mr. VIVIAN. I have just a brief comment on that. On page 9 of your testimony it says:

> * * * need for both broad support on all frontiers of astronomy by NSF, and support of specific areas of astronomy by NASA in order to accomplish its mission.

On page 10 you refer to the fact that:

> NASA's appropriation amounted to about one-quarter of the Federal R. & D. dollars, and it took as its goal the production of 1,000 Ph. D.'s annually, which represents approximately one-quarter of the increase which is generally considered to be desirable.

Then on page 11 there are further remarks on the split in programs. I have no objection to the split. I am trying to find out what guidelines govern the split.

Dr. DRYDEN. The Ph. D. program was an executive branch decision extending from the President's Science Advisory Committee, and the various agencies were asked to see what they could do in various parts of this program, to make up the total that it was desired to accomplish. NASA was successful in getting the funds; some other agencies were not. So in this particular instance the process that I have described to you, going through various committees of the Congress and so on, did not lead to a uniform action of the Congress on the executive branch proposal to increase the number of Ph. D.'s by 4,000 a year. But that was done as a concerted action.

Mr. VIVIAN. In other words, one might conclude that NASA made this conclusion itself as to supporting one-quarter; but you would say that it was really an administration decision?

Dr. DRYDEN. That is correct.

Mr. DADDARIO. In that regard how do you look at this program of producing 1,000 Ph. D.'s annually; is it one that will go on as long as the space program is in existence?

Dr. DRYDEN. I would doubt that it would remain at that level. In fact, if this process which I mentioned operated in such a manner that the resources of the Science Foundation were greatly expanded, then I can see some reason why we would not feel it necessary to go in as heavily.

Mr. DADDARIO. Then it does get back to Mr. Vivian's question. This is one area where in the production of Ph. D.'s you are not necessarily mission oriented; you have a tenuous relationship, but not a direct one?

Dr. DRYDEN. This is more than just a tenuous relationship, we need some relationship, we want some part of that program. The size of the program is certainly a matter which is subject to review and adjustment from time to time. In this particular instance I would feel that if there were some way by which we could get—excuse me a moment—I lost my train of thought.

I was going back to say that NASA came on the scene, you remember, with $300 million in the first budget, and has gone to $5 billion very quickly, and did draw a share of the existing manpower. We don't know that very much diversion can be proved. Actually, the Defense Department programs were going down, at a time the NASA program was growing, but we did feel some re-

sponsibility, having greatly increased the demand to do something about its replacement. Therefore, we were quite willing to cooperate in this executive decision and do our share in doing something about it.

Mr. DADDARIO. I gather then that if the Gililland Committee's findings which involve the doubling of the production of Ph. D.'s by 1970 are sound, and if it were to be decided that this is a figure that must be obtained, and if it were to become a greater responsibility of the National Science Foundation to reach this objective, and if the funds were then provided to do so, there would be no reason at all why to this extent NASA would allot funds for one-quarter of the Ph. D.'s?

Dr. DRYDEN. That is correct. The size of the program, I think, is subject to review and adjustment in the light of what is being done throughout the Government.

Mr. DADDARIO. The executive branch determined it would like to double the number of Ph. D.'s, and since you had the funds available, you were able to do it where other agencies were not?

Dr. DRYDEN. That is correct.

Mr. VIVIAN. I have a brief comment and then I would like to pass on to the next person, Mr. Chairman, since my other questions might take a considerable period of time. I think one of the merits of multiple support might be evidenced by your remarks on page 11: "We notice it has become a model for other Federal scholarship programs." Although some of the other agencies might disagree with you as to who started it, I think it is true that it is advantageous.

Dr. DRYDEN. We did not invent this process. I think it probably was done in NIH earlier than in NASA.

Mr. VIVIAN. Perhaps the statement wasn't quite as positive as it might seem from this remark.

Dr. DRYDEN. But very soon after we adopted this, it was adopted in other agencies.

Mr. VIVIAN. And I believe, in the paragraphs below, on page 11, you are saying in part the following: That when a given agency has relationships with a number of members of the teaching staff of, say, a given university, that person tends to turn out students who themselves are interested in your programs, who might otherwise go on to other areas. It is not that they are necessarily forced into your zone, but simply that they develop an interest; and it stays with them afterward?

Dr. DRYDEN. They have an opportunity to develop an interest in it, and we think we will get a sufficient number for our purposes without distorting the whole picture because we place no requirements that they come into our program.

Mr. VIVIAN. I saw this very strongly in the past in several universities where even though very attractive programs were offered at fairly good salary rates, where all the considerations were favorable, it was very difficult to turn persons from endeavors of a lifetime into a totally new field, even though the field itself was attractive. You have to develop graduate students from the beginning.

Dr. DRYDEN. You have to begin young. We found that, in the old NACA, rocketry and jet development was not being taught in univer-

sities at all. We had to catch the students and train them ourselves.

Mr. DADDARIO. Dr. Dryden, I am pleased you were able to come this morning. We hope we will be able to send you additional questions which we don't have time to ask you today.[1]

Dr. DRYDEN. I will be very glad to provide the answers.

Mr. DADDARIO. Thank you, Doctor.

Our next witness is the dean of the Graduate School of Public Administration of Harvard University, Dr. Don K. Price. We are very happy to have you here this morning. The members of the committee know that you have been extremely helpful to us in the past, and we are anxious to listen to you on this subject.

STATEMENT OF DR. DON K. PRICE, DEAN, GRADUATE SCHOOL OF PUBLIC ADMINISTRATION, HARVARD UNIVERSITY

Dr. PRICE. Thank you, Mr. Chairman. I think, since my statement would probably take a bit longer to read than the amount of time you suggested, I will abbreviate it fairly considerably in the presentation and leave the text for the record.

(Dr. Price's prepared statement follows:)

PREPARED STATEMENT BY DR. DON K. PRICE

It is a pleasure to take part in this series of hearings, Mr. Chairman, because it seems to me that your subcommittee, in undertaking to review the record of the National Science Foundation, is opening up for further study one of the most significant political problems of our time: the way in which science and Government are interacting.

You suggested that I might wish to comment on the role of the Foundation, especially in relation to other agencies of Government. This covers, of course, the ways in which the Executive Branch develops its scientific policies, and the relation of the various programs of applied and basic research throughout the Government.

The Foundation, I hope most of your witnesses will agree, has been a remarkable success. It is the occupational bias of a professor to view with alarm rather than to point with pride, but today I have to face the fact that the Foundation has been a most successful political invention. But success, in affairs of state, is never a permanent thing: new problems arise for any institution just because it is successful. And the problems that we can see ahead in the Government's support of science and related educational activities warrant a careful and critical review of the principles on which the Foundation was conceived 20 years ago, 5 years before it was actually brought to birth.

Those 5 years were spent—an impatient observer might say, wasted—in debating all possible aspects of the proposed Foundation's organization and program. The main issues seem to me, as I look back on them, to fall in two categories. One was the problem of the relation of science to political authority; the other was the relation of basic science to applied science.

Of the two, the relation of science to political authority was the more fundamental, at least from the point of view of a political theorist. It caused most of the bitter argument, and led to President Truman's veto of the first bill that was passed by Congress in 1947. Could science get large-scale Federal support without running the risk of political interference? And could any type of organization be invented to prevent political interference without giving a scientific elite a privilege and irresponsible position in our constitutional system? After President Truman vetoed a bill that would have given undue authority and independence to a part-time board, one might well have thought the problem a hopeless one.

Yet in retrospect, this particular problem was solved so easily, and so much to everyone's satisfaction, that today the issue almost seems a phony one. By contrast, the problem of the relation of the Foundation, with its basic research programs, to the Government's program of applied research, and to the potential

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

new programs of research and of education, seems a much more difficult one, even though of less theoretical significance.

Perhaps the original trouble, in the 5 years after the presentation of Dr. Bush's report, arose because many scientists confused the proposal of a National Science Foundation with the idea that the Government should continue in peacetime, for civilian purposes, the type of large-scale support of applied research that had produced the new weapons and weapons systems of the war. That was not the main point of the Bush report, which argued for the support of basic research in independent institutions. But many others had in mind a broader and more practical program of Government support for science. And that idea raised in the minds of many American scientists the bogey that had dominated the debates among Western European scientists during the 1930's: the twin Marxist doctrines that science ought to be supported only for its social utility, and directed by political authority.

If the National Science Foundation in practice had so little difficulty with the issue of science and political authority, it was in part because this Marxist bogey had no relevance to the Foundation's primary purpose, nor that of the Bush report. In the first place, the proposition that science should be supported for its practical applications may have been identified with Marxism by European theoreticians, but in the United States it was an old tradition, dating back at least to Jefferson and Franklin, and honored in practice by every land-grant college and appropriation committee. What the Foundation was trying to do was to provide for the first time for a good measure of support of basic science—science which could not, or should not, be connected at the outset with a particular practical purpose. If you define radicalism as any new Federal spending, the Bush report was very radical indeed. But from the point of view of socialist theory, it must have seemed quite a reactionary document.

But these categories of radicalism and conservatism do not fit American politics very well. We are not nearly doctrinaire enough—I should say, we are too sophisticated—to make that possible. We are quite capable of expanding governmental activity and at the same time increasing the freedom of citizens and of private institutions, and this turned out to be true of the work of the National Science Foundation.

It should have been clear in theory, between 1945 and 1950, that this could be done. There are of course profound connections between a nation's politics and its religious thought, its system of education, and its basic science. But it is still possible for a nation—in particular, for the United States—to separate church and state, and maintain schools and universities that are free of political control even though supported by taxation.

But theory is never as convincing as a good experiment, especially in politics. And what we failed to learn from theoretical debate, the Office of Naval Research demonstrated for us. While many scientists were arguing that Federal grants could not be given, without destroying academic freedom, through any agency that was not thoroughly insulated against the administrative discipline of the President, the Navy did it. If a department dominated by a military chain of command, and fully subject to the Commander in Chief, could give grants for basic research without dictating to the scientists, it was obvious that the kind of freedom we sought did not depend on the details of that level of administrative organization. It depends instead on a consensus—throughout the Congress and the executive branch and the country as a whole—that our universities and research institutions should not be directed, in their scientific and scholarly concerns, from Washington, even if they needed and were given financial support. The corollary of this consensus is that many policy issues affecting science and the universities—questions like magnitude and types of financial support, the principles of its distribution, and the terms of accountability—are not issues that can be determined on scientific principles, nor by scientists. And these have to be dealt with through the normal system of political responsibility.

It is encouraging to me to note how well this kind of separation of roles—almost an informal kind of separation of powers—has worked out since the Foundation was established.

The basic procedural safeguard for the independence of scientific institutions from centralized bureaucratic control is provided not by the Board, and not by the statutory divisional committees, but by the subordinate advisory panels which review applications for the support of projects. These panels are similar in function and purpose to those that have been set up by other Federal grant-making agencies, within a great variety of departmental and agency structures.

It has become virtually an established political principle that there should be, in academic and scientific fields, no subsidization without representation.

On the other hand, we have seen the higher statutory structure of the Foundation, which was originally conceived as an elaborate system of checks and balances, evolve into something more like normal administrative machinery on normal administrative principles. Many scientists are good at administration even if they feel a professional compulsion to depreciate it. As the workload of the Foundation has increased, its structure has been adjusted to let it get its job done, and deal with its policy issues, and less attention has been paid to the original conception that 24 eminent scientists on the Board should themselves make the grants, and that the Director and his administrative staff should be kept in the background. The various steps that have been taken (by statute and reorganization plan) to permit the Board and its executive committee to delegate functions, to alter the statutory pattern of subordinate divisions, and to raise the status of the Director, all seem to me a sensible series of developments. Even more important, perhaps, is the change in the Board's own view of its role. It began by organizing itself into committees mainly to correspond with particular fields of science. More recently, it has taken a broader view of its policy role and set up its internal committees on more general aspects of the Foundation's business—such as its substantive scientific programs and their relation to national policy, the administrative aspects of its relation to grantees, and its long-range plans, especially with relation to other Government programs.

This new emphasis on policy may seem to some critics an effort to lock the barn door after the horse has been stolen. One of the most frequent complaints about the Foundation used to be that it failed to do one of the main jobs that its basic act gave it: the job of developing a national policy of basic research and scientific education, and evaluating the performance of other Government agencies with respect to that policy. To such critics, the creation of the President's Science Advisory Committee and the associated Office of Science and Technology constituted a judgment that the Science Foundation had failed.

This seems to me a fallacious criticism, I would acknowledge—indeed, I would heartily agree—that the Foundation had failed to meet the expectations of some of its original supporters, who had been encouraged by the language of its act. Nevertheless, I would argue that the Foundation's role in policy has not been diminished by the reorganization plan that transferred certain of its coordinating functions in 1962 to the OST. Indeed, it seems clear to me that the existence of the Office of Science and Technology gives the Foundation a much greater range of potential policy influence than it could have had without that Office.

Policy is not something that can be divided up neatly, even by statute, and assigned to different agencies. If it means—as I think it does—the broader aspects of any Government agency's business, the aspects that affect the affairs of other agencies and excite the attention of the public and the Congress, then it follows that it cannot be defined in advance and assigned conclusively to anyone. Within the executive branch, the President is bound to be interested and involved; within the Congress, any important policy will certainly demand the attention of both a legislative committee and an appropriations subcommittee, and probably more than one of each.

When the Office of Science and Technology was formally given responsibilities for coordinating top policies, this did not freeze out the Foundation. To be technical about it, the pertinent passage in the reorganization plan transferred from the Foundation only "so much of the functions" of policymaking as would enable the Office of Science and Technology Director to advise and assist the President. Since the ability to advise the President depends more on the President's receptivity than on any statutory formula, it does not seem to me that very much of that unmeasurable and impalpable substance was necessarily taken away from the Foundation. Regardless of the technical language here, the ability to influence policy is inherent in all agencies of the Government, and indeed in all free citizens; it depends more on what one knows and what one can do than on any formal authorization. And as long as the Foundation has the ability to make grants wherever they will best advance science, and the duty to collect and disseminate information on scientists and their research work, it has ample opportunity to help develop science policy. It could not, as a practical matter, exercise authority over the scientific programs of the other departments and agencies, even with statutory authorization to do so. But now its information and its advice, to the extent that they are persuasive to the Office of Science

and Technology and the President, have an enlarged range of potential influence.

This brings me to my second main point. While I think we were too much worried a couple of decades ago about the relation of science to political authority, we were not worried enough about the relation of basic science to applied science, with all its impact on Government programs. We are reminded how much more complex this problem is than most people could foresee in 1950 if we read again the statutory language by which the Foundation is authorized and directed, "at the request of the Secretary of Defense, to initiate and support specific scientific research activities in connection with matters relating to the national defense * * *." The idea back of that language seems rather quaint only 15 years later. Could we really ever have expected that Defense would need to look to the Foundation to run its research program for it. It reminds us how much more complex our national scientific programs are today than we would then have expected. Who would then have thought that by 1963 the National Institutes of Health and the National Aeronautics and Space Administration would each have surpassed the Foundation in the amount of basic research support awarded to universities? On the other hand, who would have expected that the Foundation, which was created to support basic research and forbidden by law to operate its own laboratories, would be in charge of the national program of weather modification, and actually running a project like Mohole?

Clearly, we are going to be engaged, as a nation, in more and more scientific research, and more and more technological programs, and some sense of policy, some general approach should guide the future decisions of the Government with respect to the relation of basic and applied research programs.

In this brief testimony, I can only outline what seem to be the desirable lines of future policy.

First, I see no point in the notion of a single Department of Science. It seems to me as useless to try to segregate science as to allocate responsibility for thinking about policy; both are parts of the job of every agency of Government.

Second, I would not try to prohibit any agency that supports applied research from supporting a small proportion of basic research along with it. The borderline between "basic" and "applied" is impossible to police. But more important, it seems to me highly desirable to have basic research supported by a variety line between "basic" and "applied" is impossible to police. But more important, of sources. An applied research program, by all scientists' testimony, is more fruitful if a certain amount of basic research is mixed with it. And from the broader point of view, it is healthy to have a multiplicity of sources of support for basic research: this pluralism, far more than any procedural rules or committee structure, is the fundamental protection for scientific freedom.

Third, I should think the National Science Foundation would do well to concentrate on its original purpose, in the main, of support for basic research and related educational activities. The Foundation is the Nation's main means for insuring that the varied purposes of agencies with particular programs do not pull science away from the lines of development that its own leaders think most fruitful. I am not particularly worried, as the system works now, that universities will seriously distort their programs of research and education in order to get Federal grants. As long as one of the major granting agencies exists to serve the purposes of basic science in general, the special-purpose agencies will have much more incentive to help support basic research without defining the scope of their interests too narrowly. There is a competition for quality projects among Government agencies, it seems to me, that helps to protect the interests of the scientist that competition might be much less effective if the Foundation did not exist to set a continuing example of regard for freedom of research at its highest level.

By this, I do not mean that I would wish to prohibit the Foundation from engaging in any applied research, or from undertaking any major projects in special fields. Obviously there may be special opportunities for the advancement of science that can be met in no other way, and that would justify exceptions. But to undertake very many programs of this kind would change the Foundation, I fear, for the worse, and alter its unique sense of mission. Moreover, it would require changes in its internal organization that might handicap its basic purpose. A major operating program will tend to demand more of the energy and attention of any executive than will the general run of smaller projects. In this case, this incentive may work against the Foundation's fundamental purpose.

A main argument for the support of basic undirected research is that the small research project may have unforeseen results of incalculable importance, while the large development project will tend to confine itself to the purposes for which it was set up. The more large programs or projects of an applied nature the Foundation takes on, the more, I fear, will its top staff be obliged to neglect the unique purpose for which it was established. I think that Dr. Waterman was very wise, a few years ago, when he recommended that the Foundation not be given a new statutory mission for administering an oceanography program, and coordinating the oceanographic activities of other agencies, on the grounds that such a mission was not compatible with the pattern of organization, and the type of staff members, through which the Foundation carried on its basic science program.

Science is so pervasive a part of modern life that I do not think that in general we should try to organize departments of Government according to their use of particular fields of science or technology. It still seems to me that each major department should include the several activities that are useful in accomplishing some broad public purpose, and that science and technology should be thought of as essential, though subordinate, means to its ends.

But basic science, like education, is an all-important kind of social overhead. It cannot be tied exclusively to any particular social purpose without being limited and distorted in its nature. It deserves a special and central place in our executive organization, for what it does can have powerful effects on nearly everything else in modern life. And it must work by unusual procedures, since it depends for its effectiveness not on what goes on within its own hierarchy, but on what it can do for a multitude of independent institutions.

If that is the purpose of the National Science Foundation, I am inclined, as I think about its future, to be less concerned about the closeness of its relationship to great agencies with technological programs like the Atomic Energy Commission and the National Aeronautics and Space Administration, than about its relationship to the basic research program of the National Institutes of Health, and to the rapidly expanding support which the Office of Education is giving to universities, and to the future program of the proposed National Foundation on the Arts and the Humanities. The other operating departments and agencies must give priority to their own special purposes, as they consider how to make use of the research services of academic institutions. But these few have a joint concern for the total health of our system of higher education that must link their interests closely in the future. How that link is to be forged I would not try to recommend or to predict today; in the United States, we can devise a great many ways to develop unity of policy when we wish to do so, and an equal variety of ways to guarantee diversity and independence. The creation of a single Department is not always the best way to approach an important purpose, though it may be.

At any rate, the most obvious lesson of the 15 years of history that we are reviewing is that it is not always easy to predict the future. That salutary lesson should excuse me if I end on a note of uncertainty. I thank you for the opportunity of meeting with you today.

Dr. PRICE. It is a pleasure to take part in this series of hearings because it is opening up for further study a subject in which I have been very greatly interested. You suggested that I might wish to comment on the role of the Science Foundation especially in relation to other agencies of Government. This, of course, involves the ways in which the executive branch develops and coordinates its scientific policies.

The Foundation, I hope most witnesses before you will agree, has been a considerable success. It is the occupational bias of a professor to view with alarm more than to point with pride, but I do think I must face the fact that the Foundation has been a highly successful political invention. But in matters like this success is never permanent. New problems arise for any institution just because it is successful, and the problems that we see ahead warrant a very critical review of the principles on which the Foundation was conceived 20 years ago, 5 years before it was actually brought to birth. Those 5

years were spent, or maybe wasted, debating all sorts of issues of organization and program. They fell into two categories it seems to me. One was the problem of the relation of science to political authority, and the other was the relation of basic science to applied science.

Now, the relation of science to political authority seems to be a political theorist, to be the more fundamental issue, and it caused most of the argument. It caused, of course, President Truman's veto of a bill that would have given undue authority and independence to a part-time board. And yet in retrospect this particular problem seems to have been solved so much to everyone's satisfaction that the issue today seems almost a phony one. By contrast, the relation of the basic research programs of the Foundation to the Government programs of applied research and to the potential new programs of research and education seems a much more difficult one.

Perhaps the trouble came because scientists were worried at the end of the war that we might be trying to continue wartime organization of science for civilian purposes, disciplining science and controlling it along the lines of Marxist philosophy. That philosophy included two ideas, first, that science ought to be supported for its social utility, and second, that it ought to be directed by political authority. The postwar debate seemed to be about these ideas. Much more than about the idea that Dr. Bush had actually proposed. Of the two notions which in the debates of that period tended to be identified with Marxism, only one was really uniquely Marxist. The proposition that science ought to be supported mainly for its social utility was one of the oldest American traditions, going right back to Jefferson and Franklin, and I think this proposition needs to be separated very carefully from the question whether science should be politically controlled.

We are not doctrinaire enough—we are too politically sophisticated—to connect those two ideas: it has instead proved possible to expand governmental activity in a field like this and at the same time to increase the freedom of citizens and of private institutions, and I think this has been true of the work of the Science Foundation.

Now, it could have been and was argued at the time in theory that we could indeed support science, including basic science, without controlling the internal administration of universities. The theoretical arguments, as is often true, did not impress anybody very much. But what we failed to learn from theoretical debate the Office of Naval Research came along during the period after President Truman's veto of the original Science Foundation bill and demonstrated for us, and it was quite clear that if within a department under a military chain of command we could give basic research grants to universities without interfering with their freedom, it was quite clear that a civilian agency could do so and that the precise details of its top organization were not all that fundamental.

The basic protection of freedom did not turn on these administrative details, but on our national consensus that our universities and our research institutions, even if they needed and were given Government financial support, should not be directed in their scientific and scholarly concerns from Washington.

This consensus is in a way the opposite side of the coin from the belief which is I think equally fundamental, that the major policy is-

sues affecting science and the Federal relation with universities, questions like the magnitude and the types of financial support and the principles of its distribution and the terms of its accountability, are not issues that can be determined on scientific principles nor by scientists or academicians. They have to be a part of the normal system of political responsibility. And the distinction between the two types of issues is not an impossible one for us to work out in this country. It amounts almost to a new kind of separation of powers in this new set of administrative relationships.

If we try to apply these general observations to the Science Foundation itself, it suggests that the best procedural safeguard for the independence of scientific institutions from political control has not been provided primarily by the Board of the Science Foundation, which was expected to be the great safeguard at the beginning, not even by the statutory divisional committees, but by the subordinate advisory panels which review applications for the support of projects. These panels are quite similar in function and purpose to those that have been set up by other Federal grant making agencies, most of which are not headed by independent boards. It has become virtually an established political principle that in a field like this we should not have subsidization without representation.

On the other hand, we have seen the higher statutory organization of the Foundation, which was thought of as a kind of system of checks and balances, evolve into something much more like normal administrative machinery on normal administrative principles. The original idea that the 24 eminent scientists on the Board should really make the decisions and the Director and his administrative staff should keep in the background was really not an idea that could work at the scale of business that the Science Foundation got into. The various steps that have been taken over the years, both by statute and by reorganization plan—they are beautifully summarized in the report which was prepared for you by the Science Policy Research Division—seem to me to permit the Board and its Executive Committee to delegate functions, to alter the statutory pattern of subordinate divisions, and to raise the status of the Director in ways that have been highly sensible from the administrative point of view. And moreover, they have let the Board itself adopt a more effective policy role.

When they began, the Board organized itself into committees which corresponded with fields or disciplines of science. More recently it has taken a broader view of its policy role and set up its internal committees on more general aspects of the Foundation's business—its substantive scientific programs, the administrative aspects of its relations to grantees, and its long-range plans, all of which constitutes a new emphasis on the broad policy aspects of the Board's business.

Now, this new emphasis may seem to some critics to be an effort to lock the barn door after the horse was stolen, because one of the complaints which academic critics in particular made about the Foundation a few years ago was that it had failed utterly to do one of the main jobs that its act gave it, the job of developing a national policy of basic research and evaluating the research performance of other Government agencies. And to these critics the creation of the President's Science Advisory Committee and then the later creation of the Office of Science and Technology constituted a judgment that the

National Science Foundation had failed. This seems to me to be basically fallacious. I would heartily agree that the Foundation never did much, if anything, about policy coordination and program coordination, but I do not think that the Foundation's role in policy was diminished in 1962 by the reorganization plan that transferred some of its nominal coordinating functions to the OST. The Science Foundation had simply never been able, as Dr. Waterman himself acknowledged in his testimony on that plan, to undertake this policy coordinating responsibility.

It seems to me that policy is not something that you can divide up neatly, even by statute, and put in one place or another. If it means the broader aspects of any Government agency's business, the aspects that affect the affairs of other agencies and excite the attention of the public and the Congress, I think it follows that it cannot be defined in advance and assigned conclusively to anyone. I would even say that we ought not want to do that because on problems with this range of importance within the executive branch the President is bound to be interested, and the basic decisions if they can't be made by agreement among the agencies have to be made by him and within the Congress. Any important policy will certainly demand the attention of both a legislative committee and an appropriation subcommittee and probably more than one of each. So, when the OST was formally given some responsiblities for coordinating top policies, I do not think this froze out the Foundation. To be technical about it, that pertinent passage of the reorganization plan transferred from the Foundation only—as the phrase read—"so much of the functions of policymaking as will enable the Office of Science and Technology's Director to advise and assist the President." This doesn't seem to me to have taken away very much of that impalpable substance from the Foundation. As long as it has the ability to make grants wherever they will best advance science and the duty to collect and disseminate information on scientists and their research activities, the Foundation has an ample opportunity to help develop science policy.

It never, as a practical matter, could exercise authority over the scientific programs of the other agencies even with statutory authorization, but now I think its information and its advice, to the extent that they are competent and persuasive, have an enlarged range of potential influence.

Mr. DADDARIO. Do you think that is one of the major factors involved here? Because it was a new agency, it could not in fact have exercised such control over the research efforts going on in the other agencies anyway. Therefore, it was wise to move some of that responsibility closer to the President where the necessary power and control could be generated?

Dr. PRICE. Well, a lot of my fellow students of administration like to make a lot of the argument that no one operating department or agency can very well exercise coordinating authority over other departing departments and agencies, that this can be done only from the Executive Office of the President. I think there is something to it: but it is not quite so clear as all that, because after all the State Department and the Justice Department are operating departments and agencies and they do act as the President's staff agencies. But I think

the trouble about the Science Foundation ran somewhat deeper, in two ways:

(1) It was headed by a Board made up mainly, except for the Director, of part-time people, and it is hard for that kind of a board—it is impossible for that kind of a board to be around when the specific issues come up on a day-by-day or week-by-week basis. It is impossible for them to run into the Presidents' office when they need his support on an informal and easy basis, and it is not always possible for them to make up their minds and agree on issues. So, if you want an operating agency to assume (under the President, as is essential to our constitutional system) executive coordinating responsibilities, I do not think it can be headed by a board.

(2) I think the other problem is almost equally fundamental. If the Science Foundation is going to deal mainly with basic research, and later in my prepared testimony I make something of a point of this, it has to be organized in such a way as to understand and appreciate the problems of the basic disciplines of science. This means almost by definition that it is not going to be set up and staffed so as to understand the major operational programs of the Government. It is going to be made up of people who know about physics and chemistry and biology. They are not going to be people who understand the space program and the public health program and the military weapons program. So, I think it would have distorted its whole program to have tried to staff itself up to understand the relevance of fields of science to the operational programs of these agencies. As Dr. Dryden explained so well a little while ago, I think as long as the basic decisions of the operating agencies, the mission-oriented agencies as the phrase goes, have to be made primarily on the basis of their major purpose, I do not think you can afford to let an agency set up with a basic science mission tell them what to do about their jobs.

Now, this comes back to what I think is the absolute fundamental. It seems to me that the major departments and agencies of the Government ought to be set up not to correspond with fields of science. That would lead you, whether you liked it or not, into a system in which engineers and scientists would have an edge in making the basic policy decisions. They ought to be set up, it seems to me, to correspond with major public purposes, a system of organization which lets the administrators with general responsibilities and their superior political officers make the basic policy decisions from time to time. I think this is fundamental to our system of responsibility, and from the point of view of continuous adjustment to new political needs, it is the most effective and most efficient system anyhow.

If this is true, I just do not think that an agency like the Science Foundation can be given coordinating responsibilities, even in the sense of the limited type of authority that can be exercised by staff people in the Excutive Office. Fundamentally, within the executive branch, only the President can tell the head of the Defense Department or the Space Agency, "Look, whether you like it or not, I want you to do things this way and not that way." But short of that, his staff members in the Executive Office can exercise a lot of leadership and a lot of leverage, because they are close enough to the President to have some sense of his political purposes and some sense of the

extent to which he would wish to make adjustments in an operating program for the purpose of supporting science.

I don't believe that this can be done by an agency which, like the Science Foundation, is expected to be organized along basic scientific lines and more or less insulated from the President's political leadership. That was too long an answer, I am afraid.

Mr. DADDARIO. No, it is extremely interesting. But I think we have to take into consideration, too, that as some of these shifts have taken place, some of the mission-oriented agencies find themselves short of funds for basic research. The tendency seems to be, according to the testimony we have received to date, that they look to the National Science Foundation to fund more and more basic research. I would like your ideas on this. If in fact the National Science Board operates on a part-time basis without any staff of its own, but has to look to the National Science Foundation itself for help to put together its own work and its own advice to the Director, then it is actually getting advice from the very people who are giving advice to the Director himself. Perhaps we should strengthen the Board even though some of the shift has already taken place. We find, too, that this question of staffing is a problem in OST. They have a very small staff. It would seem to me that even though they are closer to the President, they may not be as well tooled to do the job in the future as we would like. Would it be wiser at this time to begin strengthening the Board rather than to be building a larger staff in OST to do something that can, perhaps, better be done within the Science Foundation as it now exists?

Dr. PRICE. These are problems of degree that I do not think anyone can give a final answer to. My own prejudices would be that I like to keep my eye most firmly on the operating departments and agencies, because I think that is where the big job has to be done, and in general I would like to have very small and compact staff agencies and coordinating bodies. I think the OST will be very much better operating at its present size than if you quadrupled it. I am not saying now whether it should be slightly bigger or slightly smaller.

Mr. DADDARIO. They are asking for four more people.

Dr. PRICE. That does not sound frightening to me, but there is always a temptation to see these interdepartmental fields of interest and to say if we were to multiply our coordinating agencies in size we would get the job done better, and I am not sure whether that is true in many cases.

I would hate to see within the Science Foundation any organizational step which would suggest that the entire Foundation staff is not really the Board's staff. I think to set up something like a system of checks and balances between the Board on the one side, and the Director who is a member of the Board on the other, would be wrong. If the staff is not serving the Board's purpose, I think the Director ought to be asked by the Board to get a different staff.

Mr. DADDARIO. You see a danger, then, if the Board were to set up a permanent staff of its own, separate and apart from the National Science Foundation?

Dr. PRICE. I would think that would be a very frightening prospect to me. I may be thinking too much in terms of the analogy of a

private foundation in which I once worked, but it seems to me that could lead only to confusion if you started that sort of business. Should I go back to my statement?

Mr. DADDARIO. No. There is another question I would like for you to comment further on, if you feel it is necessary. As the years have gone by and as the advisory committees have performed the function which perhaps wasn't originally expected of them—to be the basic procedural safeguards, as you put it—have we through experience begun to evolve a proper working relationship between the National Science Foundation and its responsibilities to the other agencies of Government involved in research and education?

Dr. PRICE. It seems to me basically on sound lines. I would like to go back because what I said a few moments ago may have conveyed a meaning I did not intend. I would see nothing wrong about letting the Director of the National Science Foundation build up his subordinate staff to serve more adequately the purposes of these Board committees which Dr. Wenk's report tells about, which are primarily policy committees. If the present staff which accumulates most of our basic statistics in this field were strengthened with people whose interests run more to the policy content of the problems with which the Science Foundation must deal and less with the publication of quantitative statistics, that might be a very useful thing.

I happen not to know enough about the internal workings of the Foundation to offer that as a suggestion with any great confidence, but I would not rule it out at all by what I said a moment ago, that I would not like to see a separate staff apart from the regular Foundation staff set up to serve the board. I think the Director might well wish to strengthen the Foundation's staff which works on these more general problems of science as well as the staffs that serve the purposes of particular scientific disciplines because I think the very process of making these general studies has a very powerful effect on the policy processes within the Executive Office and is bound to be influential.

May I go back then to my prepared statement, and turn to the second main point, which has to do with the relationship of the basic to applied science? Here, of course, we see the greatest contrast today with what was expected 15 years ago. Today it sounds positively quaint to suggest, as one provision of the act provides, that the Foundation might at the request of the Secretary of Defense initiate and support research related to national defense. It is hard to realize that a couple of decades ago we really thought that Defense might look to the Foundation to run a considerable part of its research program for it. But then there are other equally great surprises over two decades. No one 20 years ago would have thought that by this time the NIH and the space agency would each be greater than the Foundation in the amount of basic research support to universities.

And I do not think anyone would have expected 20 years ago that the Foundation, which was created to support basic research and forbidden by law to operate its own laboratories, would be in charge of the national program of weather modification and actually running a project like Mohole. Now, this suggests to me that the problem of the relation of our basic research programs to our applied research programs is probably more difficult than the issue which was debated so

vigorously when the Foundation was set up of the relation to political authority.

I would like to make only three points about what seem to me to be the desirable lines of future policy.

First, I do not see any point in the notion of a single Department of Science. It seems to me it is as useless to try to separate science off from operational programs as anything else that is an essential support to operational programs.

Second, I would not try to prohibit any agency which does applied research from supporting a small proportion of basic research along with it. The arguments for this were well outlined by Dr. Dryden, and I don't need to repeat them.

Aside from the need for a multiplicity of sources of support, I think that it is extremely fruitful and invigorating for any applied research program to have a certain amount of basic research mixed in with it.

But third, I should think that the National Science Foundation would do well to concentrate in the main on its original purpose of support for basic research and related educational activities and not get pulled too deeply into programs of applied research. It seems to me that only as long as the Foundation concentrates on basic research will it in a sense keep the great mission-oriented agencies on their toes in their support of basic research by setting high standards of quality and competence. We build a lot of free competitive enterprise into our governmental structure, and I think this is a very good thing indeed and one of our main safeguards.

If the Science Foundation would get to be more like the operating agencies, more interested in applied research and development, I think its standard-setting function would suffer. I do not suggest by this that I would wish to prohibit the Foundation from engaging in any applied research or from undertaking any major projects in special fields. There may be special considerations that would justify such undertakings. I suppose, although I know very little about either one of them, the weather modification program and Project Mohole were justified in this way.

Mr. MILLER. Mr. Chairman, I am very happy to hear this. Isn't it true, Doctor, that there are programs such as weather modification and oceanography that do not find themselves within any one department of Government? Whom would you turn the Mohole over to? You would have competition within the Government to see who is going to do this job.

Dr. PRICE. And I think you can overdo the competition within Government.

Mr. MILLER. You certainly can.

Dr. PRICE. It is awfully easy to be a Monday morning quarterback. This is a problem where I could not, as I think back, think of an alternative I would have suggested if you had asked me at the time that it was being done. But you may remember the line in Gilbert and Sullivan "What, never; well, hardly ever." I would simply say I hope this does not become necessary too often.

Mr. MILLER. I think we join you in that.

Dr. PRICE. Oceanography I think is a little bit different. Project Mohole was a big single specific job that had to be done. I think Dr. Waterman was correct in believing that it would be unwise for the Science Foundation to be given the coordinating responsibility for the oceanography program because that seems to me to be a program not involving a single project but the opposite. Its problem is that so many agencies are in the act that the problem of devising a coordinating system is very difficult.

Mr. MILLER. That is one of its weaknesses now. There is no question of that. So far as Mohole is concerned, we conceive of it in connection with oceanography merely because we decided to drill the hole at the bottom of the ocean. If we had gone out on dry land, it would have been a different story.

Dr. PRICE. I really would not like to sit here and suggest that I am an expert on Project Mohole or know how that troublesome history could have been made better. I really do not know that story very well.

Mr. MILLER. I think that out of Project Mohole we learned a great deal. We did a little creeping and a little falling occasionally, but the child is coming along fairly well now.

Dr. PRICE. In administration as well as in science I think we have to learn by trying things that do not work as well as by trying things that do.

If I may go on to my concluding remarks, I think science is so pervasive a part of modern life that I do not think that in general we should try to organize departments of Government according to their use of particular fields of science or technology. It still seems to me that each major department should include the several activities that are useful in accomplishing some broad public purpose, and that science and technology should be thought of as essential, though subordinate, means to its ends.

But basic science, like education, is an all-important kind of social overhead with a powerful influence on our national purposes. It cannot be tied exclusively to any particular social purpose without being limited and distorted in its nature. It deserves a special and central place in our executive organization, for what it does can have powerful effects on nearly everything else in modern life. And it must work by unusual procedures, since it depends for its effectiveness not on what goes on within its own hierarchy, but on what it can do for a multitude of independent institutions.

If that is the purpose of the National Science Foundation, I am inclined, as I think about its future, to be less concerned about the closeness of its relationship to great agencies with technological programs like the Atomic Energy Commission and the National Aeronautics and Space Administration, than about its relationship to the basic research program of the National Institutes of Health, and to the rapidly expanding support which the Office of Education is giving to universities, and to the future program of the proposed National Foundation on the Arts and the Humanities. The other operating departments and agencies must give priority to their own special purposes, as they consider how to make use of the research services of

academic institutions. But these few have a joint concern for the total health of our system of higher education that must link their interests closely in the future. How that link is to be forged I would not try to recommend or to predict today. In the United States, we can devise a great many ways to develop unity of policy when we wish to do so, and an equal variety of ways to guarantee diversity and independence. The creation of a single department is not always the best way to approach an important purpose, though it may be.

At any rate, the most obvious lesson of the 15 years of history that we are reviewing is that it is not always easy to predict the future. That salutary lesson should excuse me if I end on a note of uncertainty. I thank you for the opportunity of meeting with you today.

Mr. DADDARIO. Mr. Chairman, do you have any questions of Dr. Price?

Mr. MILLER. No; I haven't any questions. I want to congratulate and thank Dr. Price, though, for the very fine statement he made. I found myself in substantial agreement with nearly everything he said.

Dr. PRICE. Thank you, Mr. Miller.

Mr. MILLER. Thank you, Doctor, for coming here.

Mr. DADDARIO. Does that include the note of uncertainty with which he ended his remarks?

Mr. MILLER. If we could resolve all those "notes of uncertainty" in the field of science and its relation to government, maybe we wouldn't be here. It wouldn't be such an interesting and an engaging subject. Is that right, Doctor?

Dr. PRICE. I certainly think so.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. I really wanted to compliment Dr. Price on a matter of, shall we say, English. I thought for a person who comes from an area famous for the Boston Tea Party that the remark "no subsidization without representation" was applicable.

Dr. PRICE. Thank you, sir; but I have to admit that I don't originally come from that area.

Mr. VIVIAN. We will give you temporary credit for it.

Mr. DADDARIO. He comes from one of those areas that Mr. Roush is always talking about.

Mr. VIVIAN. I would like to go on to another matter. I gather it is still true that the foundation is forbidden by law to operate its own laboratories, is that a correct statement?

Dr. PRICE. I believe it is, as I read the legislative record here.

Mr. VIVIAN. Supposing the laboratories were floating laboratories, would that be acceptable or not?

Mr. MILLER. Don't get too technical.

Dr. PRICE. I don't really know what that term means.

Mr. VIVIAN. In that case I won't refer to any Mohole ships or anything similar. I come back for a moment because of the remarks made about Mohole, oceanography and weather modification—these all to some extent fit under a label called environmental science. There was some interest or some action in this direction to create a haven for a large number of projects which are now split into thoroughly divided authorities. Have you any comments on the wisdom or lack thereof in establishing such an organization within Government?

Dr. PRICE. It seems to me that among the many proposals which carried the label of "Department of Science," and they were so varied that it hardly makes sense to talk about them without being specific, the one which Lloyd Berkner first suggested, which was really an environmental science department, seemed to me to make the most sense. The recent reorganization plan that was submitted to create within the Department of Commerce, an Environmental Science Service Administration, seems to me to be a very sensible step in that direction. If one were to ask the question whether, now that that is set up in the Department of Commerce, we should proceed further to strengthen it and the Department of Commerce as the haven for environmental science generally, then I think you raise two kinds of questions. I don't think I have any specific answer to them, but I think it helps to define the questions. First, in any given instance, would it be better to push this field of science as a basic field, which might suggest that it be kept in the Science Foundation, or as an applied science, which might suggest the Department of Commerce? Second, if it were clearly in the applied field, are we willing to back Commerce all out here at the expense of Interior and Agriculture, because their purposes, too, have to be taken into account if you get to talking about environmental sciences in a broad way?

I don't think these questions are easily answered, and without really digging into detail on any particular proposal I don't think it makes very much sense for me to try to suggest a precise formula.

Mr. VIVIAN. You have no strong recommendation with regard to that particular proposal?

Dr. PRICE. I certainly do not.

Mr. VIVIAN. You made a comment against a Department of Science, and you would not construe that as prohibiting this particular proposal?

Dr. PRICE. Not a bit. I don't think that proposal calls for what is usually considered a Department of Science. I would assume that it would not include the Science Foundation. I assume it would not include Atomic Energy or the Space Agency or the military research programs or most of the Agricultural research programs. The question whether you would want to put together those bureaus and agencies now scattered among many departments which deal with man's environment is a rather intriguing one. I think there is a good bit to be said for it. The disadvantage is that you would tend to pull them out from their close relationship with operating programs and operating purposes. You have to weigh that against the potential advantage of linking them with other scientific programs under a head who is interested in science as such. I don't think there is a conclusive answer on that.

Mr. MILLER. Doctor, isn't it true, though, that some of these agencies find themselves in certain departments of Government for historical reasons that have long ceased to be valid? Let us take the Coast Guard. It has a great academy and it has ships stationed in the ocean continuously, its icebreakers and ice patrol, where great work could be done in the field of oceanography.

The Coast Guard finds itself in the Department of Treasury which has no work related to this merely because once upon a time it was a police organization. Its job was to keep smugglers off the coast from

coming in during the fog with small boats and bringing contraband goods to shore; and later it was used to police prohibition. But it has no present interest in the Treasury, and the Treasury has no present interest in it.

Dr. PRICE. As a former Coast Guard lieutenant, I don't know if I should comment on this. I realize there is a great deal of truth in what you have said about the Coast Guard. It was in the Treasury as Public Health was once in the Treasury. I think if one were to consider its proper place in Government today you could have quite an argument about where it best belongs. I would think Commerce with its responsibility for the regulation and the safety of commerce, in view of the Coast Guard's merchant marine safety functions, which after all used to be in the Commerce Department, would be a claimant. The close relationship of the Environmental Science Agency would add some powerful arguments in that direction. On the other hand, as I remember working on the waterfronts during the Second World War, there were still fairly close relationships with the Customs Bureau. How strong they are today, I don't know.

Mr. MILLER. I think this is very true, but I think we have lagged in some of these things. It wasn't up until about 8 years ago that we cut the umbilical cord of the Coast and Geodetic Survey. Until that time, it could not operate beyond the continental limits of the United States unless by contract with the Navy.

Dr. PRICE. I would think that the closest relationships of the Coast Guard would seem to be with the agency of the Government that has the major responsibility for transportation and a secondary responsibility for environmental science.

Mr. MILLER. I think that is very true. Personally, I think it belongs in the Commerce Department. I tried to put it there once, but not successfully.

Dr. PRICE. I once had a hand in such a recommendation, too, but equally unsuccessfully.

Mr. VIVIAN. I would like to go on, if you don't mind, with the remark you make about the relationship between programs of the National Science Foundation and particularly the Office of Education, the National Institutes of Health and the new Foundation of Arts. I would say the relationship with NIH is not necessarily a very troublesome one at the moment, but I can conceive the Office of Education being a very difficult one as the years go by and as that Office obtains more and more funds. Do you have any remarks to make on that subject?

Dr. PRICE. Yes, I think this is a relationship that could be troublesome and could be highly constructive and highly important. Perhaps I am too much influenced by the fact that I am now in a university and I tend to see the thing a bit from a university perspective. But to the extent that the Office of Education becomes concerned with higher education—and up until recently it was not very much concerned—I think it really ought to be deeply involved in the programs which the Science Foundation got into. It is impossible to separate research and education in practice, in actual operation, particularly at the graduate level. There is a lot of talk about whether we are supporting too much research and not enough education. At the level of graduate instruction I think any effort to separate the two is very

artificial and leads to a great many difficulties. Since the Federal Government decided to go into the support of research but didn't want to get involved in educational support of a general nature, it led to some fairly artificial distinctions, so that the Science Foundation began to do things that the Office of Education—if it had been somewhat more generously financed—might have gotten to first.

If I were looking, say, a half century ahead, and I emphasize that to make it clear that what I am saying is in no sense an immediate recommendation, if I were looking a half century ahead, I would find it very hard not to think about a department which would be concerned with the overall health of our system of education, including research.

It need not be a tightly organized department on a hierarchical basis. It could be a very loose confederation of agencies. I would find it easy to imagine that it would include much of what is now in the Office of Education and the basic research programs of NIH and the Science Foundation, and any new foundation in the humanities and arts field, and then maybe other basic research outfits like the Smithsonian. But I don't think the time is ripe for that yet. I say that only to suggest that I think these are the developing new fields of related interest that have to be watched very closely with respect to the coordination of Federal policies in the near future.

Mr. Vivian. Now, the National Science Foundation has been doing a great deal of work in the training of science teachers. The National Institutes of Health has a somewhat similar activity in the health sciences. The NIH people come under HEW, but the National Science Foundation which also performs an educational function does not. Therefore, if one looks at this objectively, you discover that there should be some relationship to NSF and the Office of Education under Dr. Kappel. On the other hand, to consider this is hearsay to some extent to those currently engaged in these departments; therefore, I recognize even making the remark may not be appreciated.

Dr. Price. I feel much the way you do. I do think that the basic research programs of the National Institutes of Health, while it undoubtedly contributes to the public health function in the same way that the physics program of the Science Foundation may contribute to the atomic energy or military purposes, is really the great supporter in the world of life sciences, basic life sciences. If you take the long-term view, so as to exclude any concern with departmental reactions and interests, it is very hard to keep such basic research support apart from general educational support. I think we have been providing by the backdoor method of research grants a great deal of general educational support, and we probably would do better in the long run to face up to the question and say we are going to support higher education as such. Now, this is not to say that I would like to see us get very far away from the project grant as the fundamental way of dong business in this field. I would hate to see it cut down to less than half of the Foundation grants to universities because it is a system which makes it possible to make grants without raising the specter of political control of higher education. But there is no question that if you go on only with the project grants, just as if you go on with the directly awarded fellowships to individuals, you are going

to continue to build up particular fields of science at the expense of other parts of education.

Similarly, if we are going to be concerned about the institutions which are now not among the small number of leaders, I think the way to do it is very frankly to face the problem that we want to support and build up some centers in regions and areas which don't have first-rate institutions now, and do it by giving grants for that explicit purpose. I think to impose artificial quotas on project grants or individual fellowship grants which are supposed to be made on standards of pure merit causes trouble and debases your standards. I would much rather see the problems faced frankly, and general educational support and fellowship grants given to the universities and colleges concerned if that is the purpose to be accomplished. Private foundations were equally leery a dozen years or so ago of this business of direct general educational support because it requires such a troublesome kind of decision. It in effect means that you must say we are giving to university A and not to university B because we think university A is better than university B, and this is as difficult a decision to make politically for private foundations are for public agencies. But I don't think there is any way to get out of this if you are really going to try to force a geographic distribution of quality in this business.

Mr. DADDARIO. By which I take it, you mean we should?

Dr. PRICE. If I may be personal, when I was with the Ford Foundation I was very strongly in favor of balancing our project grants which tended to go to the blue ribbon institutions with deliberate general purpose educational grants to selected parts of the country—including the one from which I came, which probably had something to do with my point of view—just for the purpose of achieving a better regional distribution. That action was not taken by the Ford Foundation until well after I left it, which probably shows I was ineffective as an adviser. But it was taken, and I think it was a wise decision, and I hope the Federal Government will face up to this some day. But it ought not to fail to recognize that this will be a very difficult job and it will involve real political troubles. Everyone is for it in general, or at least the majority of the people may be for it in general. But discriminating decisions have to be made and this isn't easy. And if you are going to do it you cannot simply do it by giving every accredited institution an equal amount of money. This would really be just a waste of resources.

Mr. DADDARIO. Mr. Yeager, do you have any questions?

Mr. YEAGER. Yes.

You would recommend, then, that the percentage of this NSF budget might be revised somewhat along the lines of taking more advantage of the institutional grants, possibly at the expense of the project grants?

Dr. PRICE. If it is necessary; yes. It seems to me they have been moving quite sensibly, slowly, and gradually in this direction, still tying the institutional grants, as I understand it, mainly to some percentage of previous project grants.

This has the great advantage of not departing from the criterion of competitive merit in some sense. I am not sure when the time will come to depart from that and frankly make institutional grants not

in relation to protect grants in any sense. But I think it is a decision that has to come sometime.

Mr. YEAGER. I have one other question. Do you see any difficulty in the situation where some of the members of the National Science Board are also members of the National Academy of Sciences, which makes recommendations for NSF functions, the President's Science Advisory Committee, or the Office of Science and Technology? Is there a situation in which we have the prosecutor, judge, and jury all bound into one? Is this a difficulty, and if so, is there any way of avoiding it?

Dr. PRICE. If I may take your question and try to break it into two parts, I think there are two questions; one, the question of genuine conflict of interest on specific grants. I take it this is not what you are mainly concerned with. I have not been on the inside of this process. From what my friends tell me, I am inclined to think that they rather lean over backward to avoid this kind of favoritism.

If you get to the second more general question, do we get an inadequate spread of general policy opinions as long as there is this much interlocking of personnel, I think we probably do not, but I don't know what to do about it, and I think this is inherent in human nature and human institutions. If the National Academy of Science is expected to include the blue ribbon scientists in this country, we would not want to pass a law that the Science Board should not include any first-rate scientists. I would think that we would wish to rely in matters like this on the fact that they are both pretty big institutions. The Science Board is not made up exclusively of members of the Academy. It has a very good geographic distribution.

And besides, the whole structure that we are actually talking about is so pluralistic anyhow that I should think it would be very easy for this committee and private scholars in the field to get on the inside and know what the issues are and what the divisions of opinion are, and whether there is in fact any sort of clique operating here. It is not my impression that this is a serious problem. It is my impression that it is a chronic and pervasive problem in society, but I don't see it as being serious in any peculiar sense in this field, and perhaps rather less in this field than in most.

Mr. YEAGER. Thank you.

Mr. DADDARIO. We would like to send some additional questions to you. We will try to keep them to a minimum.[1]

Dr. PRICE. I will be delighted to try to answer them for you.

Mr. DADDARIO. I want to thank you for your testimony and for your answers to the questions. They were very helpful to this committee and to its objectives.

This committee will adjourn to the same place tomorrow morning at 10 o'clock.

(Whereupon, at 12:15 p.m., the committee was adjourned to reconvene Thursday, July 8, 1965, at 10 a.m.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

THURSDAY, JULY 8, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. The meeting will come to order.

Our first witness this morning is Dr. Alvin M. Weinberg, who is the Director of the Oak Ridge National Laboratory. Dr. Weinberg previously appeared before this committee with the panel that presented the National Academy of Science's report on "Basic Research and National Goals." We are very happy to have you with us this morning, Dr. Weinberg.

STATEMENT OF DR. ALVIN M. WEINBERG, DIRECTOR, OAK RIDGE NATIONAL LABORATORY

Dr. Weinberg. It is a very great pleasure to be here again, Congressman Daddario.

I have a statement which I will read for the record, if you would prefer it that way. This statement is called the "Future Role of the National Science Foundation."

Most of my views on the role of the National Science Foundation have already appeared in my contribution to the National Academy report on "Basic Research and National Goals." I shall summarize the argument I presented there favoring a greatly expanded National Science Foundation, especially as a source of support of university-based physical science.

The argument is simple:

Table I.—*Federal obligations for conduct of basic research*

[In millions of dollars]

Department or agency	1962	1963	1964	Estimated 1965	Estimated 1965
NSF	105.5	144	170	212	290
HEW	190	236	265	298	330
DOD	178	198	260	293	324
AEC	192	219	238	260	286
Interior	30	29	33	37	41
Commerce	16	21	22	24	27
Agriculture	50	56	62	82	85
Other	8	9	1.5	1.8	1.4
NASA	316	447	756	910	888
Total	1,085	1,359	1,808	2,118	2,272
Percent supported by NSF	9.2	10.6	9.4	10.0	12.7

I obtained table I from the report "The National Science Foundation—General Review of Its First 15 Years." Incidentally, I might say I enjoyed reading that report very much, and I want to congratulate Dr. Wenk and the other members of the Legislative Reference Service of the Library of Congress for putting together a really excellent document. I thought it was a major contribution to the literature.

Mr. DADDARIO. I am pleased to hear you say that, Dr. Weinberg. It indicates that it has been read within the scientific community. We have received similar reports from other places, and had hoped that this report might be helpful both to the members of the subcommittee and to the scientific community.

I am pleased to hear from you that it has been helpful.

Dr. WEINBERG. I hope you, in turn, pass this view on to Dr. Wenk. I think he and his staff have done an excellent job.

Mr. DADDARIO. I think a few members of his staff are in the room right now.

Dr. WEINBERG. This table summarizes the funds spent since 1962 for basic research by Government agencies. According to the table, the National Science Foundation—the one Government agency whose mission is explicitly to foster basic research—has consistently supported only about 10 percent of all the basic research funded by the Federal Government. This means that each of the other Government agencies, insofar as it has supported basic research in the same spirit as does the National Science Foundation, has operated a sort of informal "NSF." We have not one NSF, but nine "NSF's." Of these, four (HEW, DOD, AEC, NASA) are in fact larger than "the" NSF.

The rationale behind support of basic research by the mission-oriented agencies is, I believe, perfectly plausible. Each of these agencies uses science and technology to accomplish its mission, the mission itself being specified by Congress. Each agency therefore has a responsibility to the basic science that underlies the technologies necessary for achievement of the agency's politically defined mission. For example, DOD, as the agency responsible for defense of our country, supports massive research at universities in, say, solid state physics or basic metallurgy because so many of DOD's mission require sophisticated technical applications of knowledge from these fields; or Health, Education, and Welfare, with broad responsibilities for the health of our Nation, supports basic research in the biomedical sciences.

The mission-oriented agencies have tended to look upon their support of basic research in much the same way as the director of an applied laboratory looks upon basic research in his institution. His laboratory's aim is, say, to devise methods of desalting the sea or of controlling fusion. These are, in fact, jobs that we are heavily engaged in at the Oak Ridge National Laboratory.

In order to achieve these ends, the laboratory director must devote significant effort to basic research in fields that he considers to be broadly relevant. The judgment of relevance depends largely upon the taste and style of the laboratory management, just as the judgment of relevance by Government agencies as a whole depends on the sophistication and experience of the agency managers. The basic research in an applied laboratory (or in a mission-oriented agency) is a necessary expense incurred by the laboratory (or agency) to maintain the sophisticated scientific environment necessary for getting on with

the applied work; or in the expectation that very new and unexpected findings of relevance will crop up; or to elucidate troublesome points that arise in the course of the applied work.

I might give a beautiful example of an incident in this connection. The members of the Committee on Science and Astronautics are aware that in the periodic chart there are the so-called rare gases—helium, argon, xenon, krypton—which are supposed to be completely inert. They are not supposed to undergo any chemical change at all. This was a fundamental fact of chemistry that had been known for, say 100 years. It happened that Bartlett at the University of British Columbia a couple of years ago noticed that xenon, in certain respects resembled an ionized state of oxygen.

Therefore, he began to question whether the inert gases really are so inert. He tried to make compounds of xenon that were analogous to compounds of oxygen, and, sure enough, he discovered that xenon wasn't inert. So crumbled a whole edifice of chemistry that had been in all the chemistry books for many years. This discovery was then picked up by our sister institution, the Argonne National Laboratory, and a whole chemistry of xenon compounds was developed.

I mention this because at our laboratory we had for many years been working on a very special kind of nuclear reactor, the so-called fluoride reactor, in which the uranium is present in the form of a molten fluoride. We noticed that when the uranium underwent fission, among the fission products there were xenon and krypton. Further, for about a year, under circumstances where fluorine was suspected to be present for other reasons, we always found that the xenon was missing. The krypton was present but the xenon was missing, and we couldn't understand where it went, since all the chemistry texts claimed that xenon cannot form any compound.

Therefore, obviously, we weren't doing our analyses very well. One engineer at our laboratory maintained that maybe the chemistry books were wrong, that xenon does form a chemical compound. Our chemists paid little attention to him; the chemists said engineers don't really know very much about chemistry. About 6 months later we learned about Bartlett's discoveries which explained the discrepancy. Bartlett's work was basic research in its purest form, but it elucidated a very troublesome point that we had encountered in the course of our applied work.

This is an example of how discoveries in basic research make a real difference in getting along with the applied business of the laboratories of our country.

To get back to the main story, over the past decade, most of the major agencies supporting basic research as a necessary overhead for the accomplishment of their applied missions have acquired a tolerant attitude toward the question as to what is relevant and what isn't relevant. This attitude is justified by the well-known unpredictability of basic research, as evidenced by the anecdote about xenon.

Of course, there are many other such examples that justify the enlightened attitude that our agencies have toward basic research.

Because the four major mission-oriented agencies, AEC, HEW, DOD, and NASA, have been willing to act as national science foundations in their support of basic research, particularly at universities, basic research in the universities has flourished.

But I believe most of the mission-oriented agencies face all but insoluble problems in their continued support of basic research, particularly at the universities. For if basic research by these agencies is viewed as a means to accomplish their politically defined, nonscientific goals, then the level at which basic research is supported by the agency ought to bear some relation to the total budget allocated to it by Congress to accomplish its mission. This is not to say that even if the budget of the agency remains stationary the agency should not allocate a larger fraction to basic research. But the degree to which any agency can or should play this game, diverting more and more money to basic research, is, I believe rightly, limited; I don't, for example, believe that our own laboratory, established to achieve applied missions, ought to become a basic laboratory simply because Congress decides that its applied missions are no longer important enough to warrant continued support. In the same way, I think an agency established to accomplish a politically defined goal should not become merely a supporter of basic research because its politically defined goal is no longer deemed to be very important. On the average, the basic research budget of every mission-oriented agency must be a reflection of the budget of the entire agency.

But this is precisely why the role of NSF seems to me to be so important in the coming years. Of the four mission-oriented agencies, HEW, AEC, DOD, and NASA, that have supported basic research most heavily in this country, three—AEC, DOD, and NASA—are devoted to missions whose importance does not seem to me at least to warrant increases in overall budget, or very significant increases in the overall budget. In fact, spending for defense, atomic energy, and space already have leveled off. Except for the great issue of civil defense (which in any case has few implications for basic science), I cannot visualize public problems lying within the province of these three agencies that would justify much expansion of their budgets. Insofar as these three agencies support a considerable fraction of our basic research, particularly in the physical and engineering sciences, it seems obvious to me that these agencies will be unable to continue to provide the growing support these sciences will demand.

The Department of Health, Education, and Welfare, and the biological sciences generally, I view in a different light. As I look at our deployment of scientific resources or, for that matter, our governmental resources, I am convinced that more should be allocated to the biomedical sciences. The elementary human suffering that more knowledge in biomedical sciences will surely help relieve is so obvious, and is so important to each of us, that I would urge all possible haste in pushing at the frontier of biomedical knowledge.

I think this view is shared by Congress and by our people. Thus, even though this year's budget for NIH has not increased as fast as I think it should, I rather confidently look forward to NIH becoming a $3 billion agency by the early 1970's, simply because the problems it addresses itself to are so important, and because the time is so right for making tremendous progress in the biomedical sciences.

Because of my conviction that NIH will expand rapidly, I have little concern about support for basic biomedical science. NIH has been tolerant and sophisticated in its support of basic biomedical sciences in the past, and I believe it will continue to be tolerant and

knowledgeable in the future. I visualize NIH greatly expanding its role as a National Science Foundation for the basic biological sciences; I believe this role is justified and strongly in the national interest. In fact, in answer to the second question put to our NAS committee by the Daddario subcommittee—and I paraphrase the question—"How should we deploy our scientific resources?" I answered, "Make the coming age the age of biology." I see no reason to change my mind on this score.

Though the biomedical sciences ought to be well taken care of over the next decade, the physical sciences, being the handmaidens of agencies that are unlikely to expand very much, can hardly expand unless some positive action encouraging such expansion is made by Congress. But first I ask, "Why should the basic physical sciences be encouraged to expand?"

In answering this question, I point out that science, by its very nature, tends to expand and to proliferate. Every important discovery, at the same time it resolves one pressing question in science, raises many other questions; more than that, it may provide a technique for examining questions which were intractable or had not been thought of before the discovery was made.

Thus, insofar as our country is committed to support of basic science, it is committed to an expanding kind of activity, simply because the internal logic of basic science forces it to expand. Science is, indeed, an endless frontier.

This tendency toward expansion is accentuated by the growing demands of our educational system. As more of our population goes to college, a larger number of students will elect to study the sciences. Insofar as our Nation is committed to providing its citizens as much education as we can afford, the growing college enrollment in physical sciences will place heavier demands on our scientific resources.

Present studies by National Academy committees of physicists and of chemists suggest that this pressure for expansion of our educational institutions will require about a 19-percent increase in university science each year.

I believe this gradual "scientizing" of our society will have important implications for many crucial public problems that we now see emerging. Most of these problems, like the despoiling of the environment, or urban transportation, or urban sprawl, do not obviously fall directly in the physical sciences. Yet the physical sciences will surely contribute heavily to our attacks on them—partly directly, as in the development of an effective catalyst that eliminates noxious fumes from our auto exhausts; or indirectly, as people well grounded in the discipline of the exact physical sciences transfer into the more complex, more difficult, social sciences. How such transfer might work has been demonstrated to me at the Oak Ridge National Laboratory where we have launched a civil defense project to examine the entire question of civil defense. The leader of the project, Eugene P. Wigner, is a Nobel Laureate in Physics; but he has made a partial transition to the social sciences. I am convinced that the habit of thought and background he acquired as a physicist has equipped him for a sophisticated attack on the problem of civil defense.

If we agree that the basic physical sciences ought to continue to expand, though not as fast as the biological sciences where will the money come from?

I see three major sources: First, many of the physical sciences, notably chemistry, are germane to the biomedical sciences. I therefore believe it to be entirely proper that these branches of physical science be recognized as handmaidens of the biomedical sciences, and that the burden for some of their support be assumed by NIH. To some extent this is already being done: NIH is the single largest Government supporter of basic chemistry in the universities. This is a statistic that often comes as quite a surprise to those who study this matter.

What I argue for is an expansion of this commitment to the physical sciences as the budget for NIH itself expands.

Second, as we mobilize around the new public problems I identified earlier, like the problem of urban transportation and air pollution and so on, and assign them to Government agencies, or as new agencies are established to deal with them, these new agencies ought to give some support to the basic physical sciences. For example, one of the newer large-scale missions of Government, the achievement of economical means to desalt the sea, has already served as a source of support for certain kinds of basic research in solution chemistry and thermodynamics. However, since most of these newly emerging problems seem to me to lie in the social sciences, I do not expect agencies or offices charged with these missions to accept much responsibility for the health of the physical sciences, even though the latter are indirectly relevant to what they do.

The main source of support for our expanding basic scientific enterprise, particularly in the physical sciences, must therefore, I believe, be the National Science Foundation. The budget of the NSF for 1965 was about $400 million, an increase of some 15 percent over 1964. I would strongly urge that this trend be maintained and even accelerated so that by, say, 1970 NSF's budget would exceed $1 billion per year. As I see it, by this time NSF and NIH would be the largest basic scientific agencies: NIH being concerned primarily, though not exclusively, with the biological sciences, NSF primarily, though not exclusively, with the physical sciences, especially in the universities, and with those aspects of science that are not properly taken care of by one of the mission-oriented agencies.

To my mind this would imply a major simplification in the way we fund science. At present, as I pointed out at the beginning of my testimony, most of our basic science is supported by our mission-oriented agencies as a justified overhead expense for the accomplishment of their missions. But these missions in general are not likely to grow as fast as the pressure to expand basic physical science.

Thus, we shall soon be unable to support our expanding basic physical science merely as assessments on relevant missions. Instead, we must decide whether basic science per se, only indirectly relevant to specific applied missions, or as an adjunct of education, should continue to receive more support from Government.

This debate is perfectly justified, and should be encouraged, not submerged. The proper focus for this debate is the National Science Foundation. As the Foundation becomes the largest supporter of basic research per se, particularly in the physical sciences, I would anticipate that the debate in Congress concerned with NSF will be the main annual forum at which the Nation decides how important we think basic research is in our scheme of things.

The debate will inevitably involve the whole question of the relation between Government and higher education. The stabilization of the budgets of AEC, DOD, and NASA hits university-based science more heavily than it does science in the Government laboratories. The size of a Government laboratory, and its budget, is determined by the needs of the agency it serves. If the agency's overall mission is not expanding, the Government laboratory supporting that mission will not expand. This does not mean that there are no pressures to expand within a Government laboratory.

There certainly will be such pressures. But these pressures are, in principle, under the control of the Congress, and are no different than the expansionist pressures of any other part of Government.

The pressures for expansion of science within the universities, on the other hand, come from the inexorable rise in population and from the "scientizing" of our culture. This pressure to expand will remain on the universities unless Congress decides, year after year, not to respond, in which case we would gradually expect a smaller and smaller fraction of our population to turn to science. This would be unfortunate.

The expansionist pressure on university science has led, in the past few years, to considerable rivalry between university and Government laboratories. The expanding universities place pressure on the mission-oriented agencies that support them for a greater share of the agencies' limited research budgets. Since a dollar spent by an agency in an in-house or contractor-operated laboratory is unavailable for science in the universities, tensions arise between the university and the Government laboratory. This was brought into the open by the Wooldridge committee, which examined the basic scientific support methods of the NIH. The Wooldridge committee suggested that basic research in the NIH's own laboratories might be cut back and university research expanded.

As a representative of a quasi-governmental laboratory, I can only view a weakening of these institutions in favor of the universities as undesirable. The Government laboratories, being mission oriented, are directly responsive to the needs of the agencies that support them. Basic research in these institutions is done because it enables the laboratories to get on with their applied missions. Take away the basic research and you will soon lose your capacity to do the applied work efficiently.

I strongly sympathize with the plight of the universities, and I strongly believe it to be in the national interest to support more university-based research. Because not much of the expansion can, as I see it, come from DOD, NASA, or AEC (since I do not approve of diverting support from the governmental laboratories to the universities), I believe university science shall have to look, much more than it has in the past, to the HEW–NIH complex—for biology—and to the NSF for the remaining sciences. Thus, in the future NSF will be even more intimately involved with the universities than it has been in the past.

Eventually, I would visualize much more than half of the university physical science as being supported by NSF. Though there are some scientific voices which suggest that provision of so large a fraction of the university science budget by a single agency would make

the entire scientific enterprise too vulnerable to the whims of a possibly unsympathetic Congress or administrator, I am much more optimistic about the future.

Our country has reached a degree of scientific sophistication where science for its own sake has become a real goal of our society. Congress has taken a generally understanding and sympathetic attitude toward this goal.

I have no doubt that, in the years to come, the debate on NSF and its funding will bring out the national attitude toward basic research, and that this attitude will be a congenial one. Such debate is the essence of our democratic process. I am confident that, over the long pull, the NSF and the universities it supports will receive a share of our resources commensurate with the great contribution they make to our society.

Mr. DADDARIO. Dr. Weinberg, you view the research departments in some of these other agencies as being National Science Foundations in themselves. As you have put that into perspective you have indicated that DOD and NASA will have funding problems when their mission objectives level off. If the amount of basic research being done throughout the Government is not adjusted during the period of time when funding is at a fairly high level. You are concerned that the overall percentage of activity which is being accomplished in the Government will come down. You recommend adjusting the amount of basic research now while conditions are favorable to the overall effort, is that correct?

Dr. WEINBERG. I am not sure I entirely understand. Are you referring to adjusting the fraction of, say, the NASA and the DOD budgets that go to basic research at this time?

Mr. DADDARIO. Yes.

Dr. WEINBERG. I think that one cannot set an absolute value on this number. I think the trend will be toward increasing this fraction as more and more of the missions of these agencies are viewed as having been accomplished. The fraction of an agency budget devoted to basic research is necessarily limited; insofar as possible it ought to be settled in advance. This would enable us to know where else we have to look to accommodate, the pressure for expansion of basic research in the universities.

Mr. DADDARIO. The trend is toward NSF and NIH being the largest basic scientific agencies. As I understand it, you think it should go in this direction?

Dr. WEINBERG. I think it is inevitable. I think it should go this way. To paraphrase what I said, I don't really see a problem with respect to the biological sciences. Because the NIH has done such a fine job and because the problems in biology are so important, the biological sciences won't really have to worry over the next decade. Support for basic research in the biological sciences in the universities won't really have to worry very much. But in the physical sciences I just don't quite see how one can do the same thing because the agencies that have been largely responsible for basic research in the physical sciences happen to be those agencies whose missions are not going to really expand, I think Congress has rather taken this view as shown by its action with respect to the DOD or the AEC or the NASA budget. The AEC budget, for example, is a little

less this year than it was the previous year. So if there is, nevertheless, real reason for expanding basic research in the physical sciences—reasons that are not directly connected with the missions of the agencies—I see no other home for this expansion except within the National Science Foundation. We will then get out on the table the question of how important we really think basic research for its own sake is, rather than always tucking such basic research under the umbrella of mission-oriented agencies.

We have generally tucked a great deal of basic research under the umbrella of the mission-oriented agencies, which is fine. What I am saying is the game cannot be played to advantage very much longer. We are at a stage in our scientific Government policy where we have to look squarely at the question of whether we are going to allow basic research in these other sciences to expand, and this comes back to what you are going to do about the National Science Foundation. I therefore, am very grateful to you and your committee for holding these hearings, because I think this question of what is going to happen to the National Science Foundation is the most important single question connected with the future of basic science in the United States.

Mr. DADDARIO. This discussion will become a very important one and I think you have added a great deal to it this morning. When you state that the mission oriented agencies have acquired a tolerant attitude toward the question of what is relevant or what isn't relevant, have you seen tendencies for this attitude to change as the budget limitations become more stringent on the mission oriented agencies and as they tend to look to another agency to do the basic research they cannot afford? In other words, at this stage of the game do they look toward NSF and NIH to do basic research?

Dr. WEINBERG. I think that is correct. I think there is no doubt about that.

Mr. DADDARIO. How might we bring more order into this situation and emphasize the importance of proper transfers at this time? Does the 15-percent increase toward the $1 billion or so in 1970 mentioned on page 9 provide sufficient funds to take care of this adjustment?

Dr. WEINBERG. I guess I shouldn't be held too strongly to the figure of $1 billion. I say "exceed $1 billion by 1970." One billion just seems like such a big number to me; by saying that NSF was a $1 billion agency, I was giving voice to my strong belief that NSF has to become a very major element in the Government; it may be by that time it should be a billion and a half or possibly even more. I think the 15-percent rate of increase for NSF is too low for the next half dozen years, and how much above $1 billion it should go I really can't say. What I am trying to do is to urge Congress to focus on this question because I see it as the central question.

With respect to this other matter of how to encourage the mission-oriented agencies to retain a tolerant attitude toward basic research, I don't really have any very clear answer. I think the mission-oriented agencies, as long as they really have an essential sense of purpose, will have to make sure that they do whatever is necessary to get on with their essential purpose. The thing that I would dislike to see happen would be that somehow the importance of what an agency is doing is deemed to be much less than it was, say, when the agency

was founded; and since an agency always has an innate desire and imperative to survive, it will, under those circumstances, divert more and more of its money to basic research simply as a means to survive. That I would be against. But I think there is some possibility that something like that might happen with some of the agencies.

Mr. DADDARIO. I don't intend to indicate that either I or this committee is in favor of their having the most tolerant attitude. It seems to me that they ought to do what is necessary. Then there should be an adjustment of the NSF's role in relationship to the other agencies such as NIH.

Mr. Brown?

Mr. BROWN. Dr. Weinberg, I consider your paper to be extremely stimulating and aiding in the discussion of these problems which we are reviewing here. In a general way, the figures in your table on page 1 and the other data that is available, indicate that currently a very substantial majority of the funds being spent on basic research are in the physical sciences. Do you think there is any basic criteria which should govern relative support of the physical and the biological sciences?

Dr. WEINBERG. Mr. Brown, you probably know that although I am a physicist I have been sort of ruled out of the physics community because of my statements about spending as much as we do on some of the more arcane branches of the physical sciences. My deep conviction is—when we ask where we are going to put our money in basic research, if we have to make a choice—that we are not spending enough in the biological sciences.

Mr. BROWN. You indicate that in your paper.

Dr. WEINBERG. At present the physical sciences are favored by a factor of 3 to 1 or 4 to 1. I think that is wrong; it should be much closer to 1 to 1.

Mr. BROWN. That makes you a traitor to the physical scientists?

Dr. WEINBERG. I used to be a biological scientist, but that is not why I think this. The sort of thing I'm talking about is so evident. We have in our laboratories some extremely worthwhile work, implicating viruses in leukemia. Now, the thing seems to be somehow very near at hand. At the NIH, for example, they have done experiments in which they have actually immunized mice against leukemia by injecting a certain virus extract. One can't help but say that it's worth just an awful lot of money to really get this thing solved, especially when he turns around and sees examples, and we have examples at our laboratory, of people in the prime of life who are struck down by leukemia. How much would it be worth to the world to have a real cure or control for leukemia? Well, I don't know. To one who is afflicted by leukemia prematurely, it is worth all the money he has. It is on this account I say that somehow we have allowed allocation to the various sciences to be warped, and we don't, it seems to me, really keep in mind the idea that our ultimate purpose as human beings is to lead the best kind of life that we can. It is on this account that if you ask me where we should put more money, I would say put it in the biological sciences.

Mr. BROWN. You are not suggesting an actual ratio but an increase in emphasis on the biological sciences?

Dr. WEINBERG. Yes.

Mr. BROWN. Let me suggest a line of thinking which might go contrary to the line of thinking that you have advanced here. The mission-oriented agencies by virtue of their missions are not going to be able to expand their contribution to basic science. Therefore, we need an increasing role for the National Science Foundation. Has it not been true in the history of recent years that as basic science has expanded new missions have been created and new mission agencies have been created? Isn't NASA itself, for example, an outgrowth of developments in basic science? And is it, therefore, not possible—to take an example, as we make breakthroughs in say population control that there would be established an agency, national or international, devoted to population control which as a mission-oriented agency would stimulate additional research in the biological sciences?

Dr. WEINBERG. Yes; I quite agree. As a matter of fact, in my paper I do speak precisely to that point, that as we see these new public problems developing we will presumably assign them either to new agencies or to new offices, and these new agencies and new offices will themselves serve as sources of support for research which is basic but which is relevant to these missions. My only point is as I visualize the situation—heaven knows my crystal ball is as cloudy as the next fellow's—I do not see these problems arising particularly in the physical sciences; rather they all seem to have a systems character or a social science character. Therefore, I don't see how to accommodate the innate tendency for the physical sciences to expand unless the National Science Foundation is expanded.

Mr. BROWN. That leads me to another point which I have brought up with some of the previous witnesses. On page 11, you have made the statement that you believe university science will have to look much more than it has in the past to HEW and NIH for biology and to NSF for the remaining science, and eventually you visualize much more than half of university physical science research being supported by the NSF. You have just made the statement that you see the problem areas developing as being those related to systems approach to social problems. Nowhere in here do we have a discussion of the social sciences. I get the feeling that you as well as many of the other scientists do not look upon these as sciences.

Dr. WEINBERG. No, I think that doesn't express my view quite accurately. I have had a fair amount of contact with social scientists in the past year because for part of our civil defense program at the Oak Ridge Laboratory we actually have social scientists at our Laboratory. I have had many discussions with them on these questions. In fact, yesterday I was reading a paper by a very excellent social scientist, social psychologist and psychiatrist called, "A Manhattan Project for the Social Sciences." I would only say the following: I really believe the problems that the social scientists are trying to address themselves to, if anything, exceed the importance of the problems that biological scientists address themselves to, but I think one has to remember that before one can pour large sums of Government money into any field of science one has to have fruitful points of departure. In the biological sciences I think I see very fruitful points of departure.

In the social sciences, much as I would like, I really don't quite see fruitful points of departure. Therefore, in response to the suggestion by this very able psychiatrist that we have a Manhattan project for the social sciences, I had to tell him that in my opinion it would be fine if we knew where to spend the money, but I don't really see where to spend large sums in the social sciences.

Mr. BROWN. Let's look at the problem of population control, for example. There are many people who say we have wasted all the money that we have spent on foreign aid and a good part of what we have spent on defense because we have done nothing about population control. Now, this isn't strictly a biological problem; it certainly isn't a physical problem. It is basically a social science problem. We can develop the contraceptive devices but how do you convince India with its culture and Africa with its many cultures or South America? I think you can see the importance of this. The problem is not that we don't have a mission, it is that we don't see the mission, and we cannot convince Congress or the scientific community of the mission.

Dr. WEINBERG. I couldn't agree more with you in this particular instance, Mr. Brown. I do think that the population problem of the world is in some sense the problem, and I agree also that the solution to it lies much more in the domain of the social scientists than of the physical scientists.

However, I guess I still would say I don't quite see how by spending let us say $300 million to study the problem of population control one is likely to assure success on the problem. Somehow, with so many of these very complicated systems and social problems, my view is that you have to take an engineering approach, that you have to do what you can with the knowledge that you have, at the same time trying to get as much knowledge as possible but not depending on having all the knowledge necessary to really solve the problem at some specific time.

Mr. BROWN. Would you have said in 1938 that with the expenditure of $200 million we could develop the hydrogen bomb?

Dr. WEINBERG. Indeed not, but I would only make the following rejoinder, and it is to the suggestion to have a Manhattan project of the social sciences. I suggested to my friend, that if one wants a Manhattan project of social sciences, he must show me the discovery of fission or the equivalent to the discovery of fission before I give him the money. As soon as he has the point of departure, I am willing to give him as much money as possible. Until he has the point of departure, until, so to speak, one has discovered fission, I think the small-scale individual kind of investigation is the sort of thing that is needed.

Mr. BROWN. I think any discovery of fission starts with a few people who understand the phenomena of fission. Einstein was evidently able to see the possibility of a hydrogen bomb when no more than 2 dozen people could see it. There are more than 2 dozen people who see the problem in the social sciences today.

My question is directed to this problem. I think the concept of fission in the social sciences is here. It may be in the population problem, or it may be in any number of other problems, but we don't seem to have that catalytic situation. An Einstein can say to a President, well, here is the potential that will allow us to get some action.

As an example of this, you probably noticed a little flurry in the papers recently about the Defense Department spending $20 million

on social science research, one of the projects being Chile. This maybe should have been funded by some other department, possibly the State Department, or possibly some department completely devoted to social science research such as comparative economics of societies or political science. We don't have such an agency now. The Defense Department can get $20 million to do this because nobody cares about $20 million in a $50 billion budget. This would seem to indicate that perhaps the problem is in the thinking of the policymakers rather than in the lack of a need for basic social science research.

Dr. WEINBERG. I want to make very clear, Mr. Brown, that I agree completely with you on the desirability of using the social sciences and the desirability of making progress in the problems that social scientists address themselves to. I suppose the only respect in which I disagree is that I don't really see how the social scientists at their present state of development, without breakthroughs of the sort that fission implied for nuclear energy, can make use of vastly greater sums.

A Manhattan project for the social sciences now—I just wouldn't understand it. On the other hand, I want to say again I respect social scientists and I would like to see them supported. I think the social scientists themselves are not complaining very much at the moment about support.

Mr. BROWN. It is just the physical scientists such as yourself who are complaining about not getting enough money for biological sciences.

Dr. WEINBERG. I should explain again I have practically been run out of the physical science community.

Mr. BROWN. Thank you.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Doctor, I am interested in your discussion of potential competition between the universities and the in-house laboratories. Is this a serious problem now?

Dr. WEINBERG. It is a little difficult to say whether or not it is a serious problem. I see it developing, and it develops for the obvious reason that both kinds of institutions get their support from the same limited source.

Mr. CONABLE. Our universities are much more dependent upon these grants than they used to be, are they not?

Dr. WEINBERG. Very much more; that is right.

Mr. CONABLE. They are almost in the same position as that of the in-house laboratories. Although they have other strings to their bow, this is an important consideration?

Dr. WEINBERG. That is right. Of course, in the universities there is an inexorable pressure to expand simply because there are more youngsters going to school. Therefore, the universities keep getting bigger and bigger, they have to provide sophisticated scientific education for more and more students, so they always go this way, that is, upward. The colleges have depended, say, on AEC for a good deal of support in basic chemistry, but AEC only has a limited budget. AEC has its own laboratories that are fulfilling missions that are relevant to its business, and just don't have the money to go around.

Mr. CONABLE. Is this competition likely to lead to some serious coordination problems?

Dr. WEINBERG. I view it as being a source of increasing difficulty as the years go by, as the financial pressure on the universities increase. Being the director of one of the national laboratories, perhaps I feel it more sensitively than people who are not in this position.

Mr. CONABLE. From your vantage point is the Science Information Exchange doing a good job?

Dr. WEINBERG. I think that is a very complicated question, Mr. Conable. I haven't really been in science information for nearly 2 years. I think at that time, as our report said, the Office of Science Information Service (OSIS) is doing some things very well, is providing information on what is going on in science throughout the country and through many of the agencies, and is supporting new publication ventures advantageously. The thing that the OSIS is not doing is really serving as an overall science information service as VINETI does in the Soviet Union—as actually an operating service. I think in much the same way as the role of the National Science Foundation as a whole has not developed into coordinating all the science of the Government, so OSIS has not been able to coordinate all the science information services in the Government.

Mr. CONABLE. Is this their fault, or the fault of the agencies not cooperating with them? For instance, does your laboratory cooperate with SIE?

Dr. WEINBERG. With SIE we do, that is Science Information Exchange. We send our summaries of research to them. With the Office of Science Information Service there has been no real opportunity for our laboratory or even for the Atomic Energy Commission to cooperate in the sense that I think you perhaps have in mind. I think the primary reason has been that the National Science Foundation, although when originally established, it was visualized as having a kind of coordinating role for all the science in Government, actually has developed into just another science agency, although a very important science agency, and it was perhaps asking too much for the Office of Science Information Service to assume the overall coordination of science information for all Government agencies. My own belief is that the Committee on Science and Technical Information of the Federal Council for Science and Technology is doing a good job and is taking over some of the functions that were originally envisioned for OSIS.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I would like to paraphrase a remark made yesterday by Chairman Miller of the full committee when he said he thought a speech was very excellent because it reflected his own views very strongly. I must say your own remarks fit into that category. I think they are very pertinent. I envy the Oak Ridge staff for having such an outstanding director.

I would like to back up some of Mr. Brown's remarks on the subject of the social sciences, but I want to refer to motivational sciences for a moment, which is only a part of the social sciences. With the advance of the physical sciences, the biological sciences have been able to move much more rapidly. For example, the improvements of instrumentation aided the biologists enormously. I think with the advance in the computer sciences the possibilities for increase in the knowhow of the motivation sciences are riper than might be suggested.

I perhaps would suggest to my colleague here that this is one of the places where the full force of present technology can be presently put to work, and with enough of a point of departure, to be productive.

I think we are all aware of the number of sufferers, say, from cancer in this Nation. There have been probably as many persons killed in Vietnam. On a microscale the number of traffic fatalities on a Fourth of July weekend exceed the number of Americans killed in Vietnam in 4 years. So the motivational sciences would be a productive area.

To go further, you mentioned "scientizing" our society. That is not so much a dedication of science but a dedication to education generally. It seems to me science in this respect is just one facet of education, and a more modern version of the same. Aren't you really saying we direct ourselves to the idea of a very much advanced education in which everybody becomes familiar with science, rather than being a devotee or practitioner of science?

Dr. WEINBERG. Very definitely.

Mr. VIVIAN. I have been using a phrase, "the image of the age," namely, that science is going to solve most of our problems in the future. I have been pointing out to a number of my audiences that research has pretty well flattened off, the numbers of dollars you can count in the private research sector has flattened off, and I am basing this on statistics collected by the Government, which are never accurate but are at least indicative. The basic and applied areas within the Government itself have also flattened off. As you have commented, DOD, AEC and NASA curves now have a very distinct flat spot on them with no gross evidence of a sizable rise. I think in the Department of Defense the only obvious reasons would be some drastic change in the defensive anti-missile-missile business which could be an enormous influence and would have tremendous policy connotations far beyond any scientific connotations. At the Atomic Energy Commission, my impression is that the new accelerator will influence the budget in the future merely because of operating costs.

I think it is a step which we will eventually have to take. The NASA budget has been leveling off. So if we take the private sector and the public sector, we find that "the image of the age" is coming into conflict with the realities of financing. We are bound to see more people trained in science with this 15-percent-a-year rise, who will have to be financed in science or related activities such as motivational activities or who will simply have to take their knowledge or talent and move into other fields of endeavor. This is a pattern which is emerging and I think your comments have illuminated this very, very well, far better than I have been able to do in the past.

I would like to go into a facet of this which you have mentioned. You suggested that a fraction as large as a half of the support for university science if it came out of NSF would be worrisome to the members of the scientific community. I am very familiar with these worries. I think they are justified but I don't think that a factor of one-half is serious. My own personal thinking is it should be at least one-half through NSF. Do you have any comments on the fraction?

Dr. WEINBERG. I think my sentence——

Mr. VIVIAN. Page 11.

Dr. WEINBERG. Didn't I say rather more than half?

Mr. VIVIAN. Much more than half.

Dr. WEINBERG. And by much more I mean 75 percent or 80 percent. Eventually, as I see the thing developing, I visualize NSF becoming the source of support for the bulk of a large segment of university science. I think you put it well, Mr. Vivian, when you state that some university scientists view this with considerable trepidation because they believe there is strength in multiple sources of support. In some sense there is strength in this, but, as I look at it, if we think that science is really important, we should be willing to argue this each year and say that science is very important and we are going to allocate a big piece of our resources to the support of Government science. Such debate would be best focused if a large fraction of our support came from a single science-oriented agency, that is, NSF.

Mr. VIVIAN. I think a a good percentage would be between 60 to 70 percent. Because NSF deals so heavily with grants rather than contracts to the universities themselves, I feel that such a large percentage is not as adverse as it would seem. I don't think it should be larger than 60 to 70 percent.

Dr. WEINBERG. I think I would agree, although I disagree with some of the implications of the statement that one must have diversity of support. I think there is some merit in having some diversity. I think even the National Science Foundation, which has been a most enlightened agency, could fall into error, and there is such a thing as keeping one agency honest by having comparisons with other agencies.

Mr. VIVIAN. Historically, the National Institutes of Health evolved through the departmental structure of HEW and have grown from a very small to a large section of that Department. The National Science Foundation has grown, too. The two are hard to differentiate. If you had a nuclear electronic testing tool as a key part of a testing tool working in biology, one is hard put to know whether it is biological science or scientific biology. To my mind this distinction is not only rather tiresome, but also rather detrimental to the progress of the interweaving of two facets of science. I had thought in the past that NIH might be wiser to be under a similar board as the NSF and more recently that NSF be put under a department as in NIH. Either of these approaches are anathema to large portions of the Washington community. Do you have any option or personal observations on that suggestion?

Dr. WEINBERG. Yes, I have an opinion.

I think it would be a mistake to put NSF and NIH together for the following reason:

I believe that basic research as an overhead on the achievement of an applied mission is a fine way to support basic research, and I see nothing wrong with that. If NIH were in the same box as NSF, then I think you would tend to dilute its mission orientation, that gradually NIH would see its purpose of getting solutions to health problems somehow attenuated and that would be wrong. I think it is very good for NIH to be a mission-oriented agency whose job it is to solve as many health problems as it can and to use basic research as one of the tools in solving these problems.

Mr. VIVIAN. How do you construe the relationship between Public Health Service and NIH?

Dr. WEINBERG. I don't really know too much about the relationship between the two. As I understand it, NIH uses research and investigation, both applied and basic, as a means to achieve the overall mission of the Department of Health, Education, and Welfare. The Public Health Service uses, I guess one would say, engineering and operations to achieve the same thing. But I think it really would be a mistake if we allowed all of our Government agencies to become nonmission oriented. I think it is important that Government agencies remain mission oriented so far as we can identify the missions and that they support basic research as a justified overhead. NSF is different; its mission is science per se; knowledge per se.

Mr. VIVIAN. Does that include biological science?

Dr. WEINBERG. Yes, as I put it in my paper it includes biological science, but because you have such a nice home for the biological sciences, it is not necessary to give very much money to NSF for that specific purpose. I hope the biologists in the audience don't think I am saying that I don't want money for biology. I do.

Mr. VIVIAN. At Oak Ridge you have persons in the social sciences studying the problems of civil defense. Although I have regard for Oak Ridge and have been there before because I am particularly interested in our fusion programs, I was rather surprised to see that you were the center for studies in the civil defense for social sciences. Does this reflect the fact that you perhaps didn't have quite the use for some of your talent that you thought you had?

Dr. WEINBERG. This is a little like the beating one's wife question, Mr. Vivian. One has to be very careful what he says because if he concedes this point, then the next question is, shouldn't his budget be reduced. I should perhaps take this opportunity publicly to say the following: I think the Oak Ridge National Laboratory is up to its ears in very important things to do; I think, however, it is deeply in the national interest that these big Government laboratories that were established for one purpose, always try to deploy against the most important problems.

Generally these important problems that we are deployed against have a strong atomic agency flavor.

In the case of civil defense there are some, notably Dr. Wigner, who believe this is one of the most important public problems that have to be looked at scientifically. Since Professor Wigner was an Oak Ridge alumnus, since he was so very interested in the problem—he had conversations with me and with the Atomic Energy Commission—one thing led to another and finally the Commission said, "Well, it is probably a good idea for Professor Wigner to bring his studies down to Oak Ridge."

So civil defense was a particular case which centered around Professor Wigner.

Mr. VIVIAN. But why Oak Ridge?

Dr. WEINBERG. As I say, because of his particular relation to the Oak Ridge National Laboratory, he knows how things are done there. He likes the way they are done there. He understands them. It was on this account that he persuaded the management of the Laboratory to make representation to the Atomic Energy Commission and the Department of Defense to have a small project started at Oak Ridge.

Of course, the Atomic Energy Commission does have a historical interest in Civil Defense, and therefore, it was not really stretching much of a point for one of the atomic energy laboratories to get into the matter of civil defense.

Mr. VIVIAN. He is certainly a brilliant individual.

Dr. WEINBERG. This is the point. It was a very special case. Here was an opportunity to get one of the foremost scientists in the world deeply involved in what many people, notably Professor Wigner and some of us, visualize as being one of those very unpleasant things, but one that we cannot ignore. We have to look at it very seriously. But I want to say again I really do believe very strongly that these big Government laboratories—if they are to serve the Nation as well as they possibly can—must always try to deploy against the real problems of the Nation; insofar as possible these problems ought to fall within the purview of the parent agency; but in some cases, they don't.

Mr. DADDARIO. Dr. Weinberg, just one question before we proceed to listen to Dr. Kimball. You referred to the National Science Foundation as having become just another science agency. Do you think it is presently structured to handle this growth which you would like to see, taking into consideration its working relationships with the other agencies, and with the Executive?

Dr. WEINBERG. Mr. Daddario, I should make clear in saying the words "just another science agency," I did not in the slightest, mean to demean the fine job of the management or the staff of the National Science Foundation. I think they have done an excellent job.

What I meant to say is there are, as I pointed out in my paper, six or seven other agencies that serve like national science foundations, and some of them are larger than the Nation Science Foundation.

As I visualize it, the National Science Foundation is going to become very much larger. I don't know very much in detail about the Foundation. Both the previous Director and the present Director of the Foundation, Drs. Waterman and Haworth are excellent people, and I have very high regard for them. As far as I understand the general structure of the National Science Foundation, with the National Science Board and a strong Director, I see no reason why that overall structure shouldn't serve a $2 billion agency as well as it does a $½ billion agency.

But I confess that I am not really very familiar with the inner workings of most of the National Science Foundation.

Mr. DADDARIO. You indicate that structurewise it seems to be all right, but that it ought to be reviewed in the event that it needs bolstering up.

Dr. WEINBERG. Probably so, although I want to make clear I don't consider myself an expert on National Science Foundation matters. If you asked me for the structure of the AEC, I could give you a more informed opinon.

Mr. CONABLE. Excuse me.

I understand you to mean that because the National Science Foundation has lost its current status, it is on the same level with the other agencies. Isn't that what you meant when you said it has become just another agency?

Dr. WEINBERG. One of NSF's original statutory missions was to coordinate the work of the other agencies, but the National Science

Foundation wasn't on a high enough level to perform this coordinating role. This coordination function had to be placed in the White House—that is, in the Office of Science and Technology and the Federal Council of Science and Technology.

Mr. DADDARIO. Thank you, Dr. Weinberg.

Our next witness is Dr. Charles Kimball, who is the president of the Midwest Research Institute of Kansas City, Mo.

We are pleased to have you here, Doctor. I regret that we have run a little behind on our schedule. I believe we have something on the order of an hour.

STATEMENT OF DR. CHARLES KIMBALL, PRESIDENT, MIDWEST RESEARCH INSTITUTE, KANSAS CITY, MO.

Dr. KIMBALL. Thank you, sir.

The invitation to appear before this subcommittee expressed an interest in my views as they pertain to the National Science Foundation not-for-profit institute relationship, what is it, and what I believe it should be, plus the supplemental role which the Foundation might play in improving the climate for applied technology.

I am privileged to appear to express my views on these important issues. I believe that I am the only witness in these hearings directly involved in the operation of a not-for-profit institute. While the views I express are my own, nonetheless they do reflect, I believe, a cross section of the viewpoints of other institutes of this type.

My statement is based on the 20-year experience of Midwest Research Institute in contract research, covering a wide spectrum of science and technology for some 1,000 different clients in Government and industry, and corollary personal undertakings, involving technology and economic growth.[1]

It is pertinent here to review briefly the position and significance, in the Nation's research establishment, of the not-for-profit research institutes, especially since the characteristics unique to these institutes are not widely known. The use of the term "not-for-profit research institute" is not specific, for there are many types of nonprofit groups undertaking research. But it is the term usually applied to organizations like Midwest Research Institute. The 10 or so major institutes of this type represent a numerically small, but quite influential, segment of the national research effort. They are a primary type of institution providing the applied science link between those who know modern technology and those who need to know. They are concerned with both generating and communicating knowledge, to governments and industries across the entire realm of the physical, life, and social sciences, as well as engineering.

[1] A joint responsibility for President Eisenhower's Conference on R. & D. for Small Business in 1957.
Chairmanship for the past 3 years of a national engineering foundation conference concerning the social and economic implications of technology.
Recent member of the Department of Commerce Technical Advisory Board.
Discussions with Governors of 12 Midwestern States concerning technology and regional economic growth.
Leadership of the first major NASA contracted technology utilization dissemination effort (since 1961 at MRI).
Member of the governing boards of several colleges, universities, and medical research institutions.

While their role is shared with a number of other groups—the universities, the corporate research laboratories, Government laboratories, and with other research organizations like Rand—the independent not-for-profit institutes are unique as a principal public-interest focus for the application of science and technology to the problems of economic growth and social change.

The Internal Revenue Service categorizes these institutes as tax-exempt organizations. Each has, to varying degrees, received tax-deductible contributions from private industries, individuals, and foundations, largely for plant and equipment. Each is controlled by a board of governors or trustees. All institute employees receive specific stated salaries, have no equity in the institutions, and receive no part of any net proceeds. None of these institutes seek contributions to defray operating costs in any substantial ongoing way. Each seeks to recover all operating costs from its project sponsors, plus an increment which is used to finance research, otherwise unsponsored, to improve experimental facilities, to fund special technical educational programs, and to provide required working capital. In most instances, the increment of income over expense permitted for projects sponsored by governmental agencies is more modest than for projects for industry.

This research institute movement started in 1913, when Robert Kennedy Duncan and Edward W. Weidlein, two young chemistry professors practicing contract research in its early form at the University of Kansas, were brought to Pittsburgh by Richard B. Mellon and Andrew W. Mellon. Thus was started the Mellon Institute of Industrial Research, and a quiet revolution in the world of professional science.

Mellon Institute illustrates very well many of the salient concepts of contract research, particularly in the formative decades from 1910 to 1940, when the corporate use of applied research needed to be convincingly demonstrated to industry. Very few companies had their own laboratories then, and few were prepared to undertake development of new products, processes, and techniques by utilizing the arts and instruments of science.

Next to be founded was Battelle Memorial Institute at Columbus in 1925; then Armour Research (now the Illinois Institute of Technology Research Institute) in Chicago in 1936. In the period 1941–47 several other institutes were founded: Southern Research Institute in Birmingham, Midwest Research in Kansas City, Cornell Aeronautical Laboratories at Buffalo, Stanford Research in Menlo Park, Calif., Franklin Institute Laboratories at Philadelphia, and Southwest Research in San Antonio. More recent organizations of this type are North Star in Minneapolis, Triangle Research in North Carolina, Denver Research Institute, and Spindletop in Kentucky, with several others now forming in Louisiana, Rhode Island, and other States.

These independent institutes have made many important contributions to basic and applied science and technology, and to regional and national issues, serving on one hand the existing, immediate, and practical needs of industry for organized research assistance, and, to an increasing extent in later years, helping meet the needs of Federal and State Governments. They have also stimulated industry

and government thinking, by identifying and developing new approaches to science and technology, pioneering in certain new technical areas of corporate business activities, and acquainting and training management and industry people in the uses and benefits of technology.

A few of the scientific contributions of these institutions provide a notion of their far-reaching effect on the development of significant technology and consequent economic growth. At Battelle, the evolution of the Xerox process is a noteworthy example. Battelle is also one of the leading metallurgy research centers in the world. The Research Institute of Illinois Institute of Technology (formerly Armour), is responsible for the basic development and wide application of magnetic recording. At Mellon, one of our great chemical research centers, research fellows have moved continuously into industry, illustrating the valuable training aspects of these institutes. Some 2,000 Mellon alumni are now in responsible R. & D. positions in government and industry. Mellon also played a key role in developing synthetic rubber during World War II and in industrial hygiene—the control of industrial waste, pollution, and disease-causing factors.

Southwest Research at San Antonio is a leader in the technology of fuels and lubricants, in the field of applied mechanics, and in transmission problems for the gas industry. Southern Research Institute at Birmingham, Ala., has one of the leading cancer chemotherapy groups in the world. Stanford Research Institute is noted for pioneer work in technoeconomics—the concept of combining market realism with technical research. Their long-range planning service is widely used by hundreds of U.S. corporations. SRI's research in electronic data processing resulted in ERMA, an automatic accounting system, which began a revolution in banking services and practices.

The Institute I head—Midwest Research—has made contributions in solid lubricants, in metal fatigue, and in cancer chemotheray, and in the utilization of agricultural products, as well as extensive programs in technology transfer. Our product and process development work for hundreds of companies and agencies has been broadly beneficial to many private and public sectors of the national economy.

These 10 major independent institutes have made many other contributions to society, as well, despite the fact that they represent compositely only a very small fraction of the total U.S. research effort. In 1965 they employed about 11,000 persons. Their research volume was about $150 million, representing less than 1 percent of total R. & D. expenditures in the United States. But their influence in their regions, on the national economy and on technological progress generally has been very much out of proportion to the relatively small dollar activity they represent.

There are many reasons for the effectiveness of these independent institutes. Research is their total activity. They cannot take narrow or provincial approaches. As a result, they must break down the traditional classical impediments between the fields of science for the enlarged benefit of the sponsor whether public or private. Their skills extend from sophisticated basic research to high utility, applied research and technology. Their findings are objective, for they have

no requirement to produce products or processes in volume quantities. Their technical and management people have been intensive users of technology, as well as generators of it, so they bridge the critical gap involved in the transfer of new technology and the economic multiplication of its applications.

At these institutes we find a blending of broad scientific interest with user-oriented values essential to the success of commercial and public missions. Here the man engaging in contract research must visualize clearly the ultimate commercial, economic or mission objectives of his work.

Over the long pull, the very life of these institutes depends on their ability to perform high quality research within competitive cost and time limitations. There is no incentive for quality, efficiency, and utility in research performance so compelling as that of survival in a competitive market. As independent laboratories, we are and have been, for decades, subject to the law of natural selection, and survival of the fittest.

Parenthetically, I note a recent statement attributable to Eric Leinsdorf, director of the Boston Symphony, and quoted in Life magazine. He says:

> To have been graced by providence with special aptitudes and abilities, maybe even with genius, does not at once entitle the bearer to present a bill to the world for remittance.

The role of the not-for-profit research institutes is changing with time, not by reduction of their activities as generators of new knowledge, or in applying science to improve products and processes, for their long record and established responsibilities would preclude a diminution of this effort. But a newer dimension is growing in importance; namely, serving as a catalyst, a coupling agent, an instigator of research, a point of focus for helping industry and government to keep technically posted and alert to change. The institutes serve also as a type of postgraduate school, retraining industrial people in new techniques. These are conducted not on a theoretical basis, but by people who are accomplished performers in their own right, working in an environment of realism, surrounded by real problems.

The research institutes are emerging as an integral part of what is coming to be known as "the knowledge industry," centers of technical authority, trusted sources of information applicable to really significant issues whose solutions may be in technology.

I have inquired of some of the institutes regarding their past relationships with NSF, and what they might be in the future, with a change of Foundation purpose.

With a very few exceptions, there neither is nor has been any appreciable contractual or grant relationship between NSF and these institutes.

The research institutes do not presently regard NSF either as a source of support or as having substantial interest in institute programs even though many institute programs are quite basic in nature. Some of their reasons for this are that NSF has considered its principal role to be the encouragement and partial support, through grants, of academic research. It has not regarded applied research as one of its responsibilities, whereas the research institutes have this as one of their major thrusts. Because of the Foundation's academically oriented

policies, it has been reluctant to depart from the grant type of support which is not compatible with the contract support programs under which the research institutes must operate.

This emphasis on basic research, the university climate or practice of grant support, the educational assistance objectives of the Foundation, all these have possibly been quite appropriate to NSF's operation over the past 15 years. Whether the intent or implied purpose of the original charter was broader than this is not the issue today. We are all operating now in an entirely different era of research, markedly dissimilar to the climate existing at NSF's beginning.

As to NSF's future role—scope and intensity—I would make some observations here about some opportunities I see in the national picture, some of which may be appropriate for an expanded NSF mission.

In making my point, I would not employ the classical distinction between basic and applied research. As an alternative, if one is needed, I would differentiate between "research for need" and "research for opportunity," the former being descriptive of scientific efforts to anticipate change, to protect against loss of corporate market position due to technical obsolescence (such as the role of EDP in automation). This is the kind of research that the textile industry and some office equipment manufacturers failed to do.

"Research for opportunity" is the nondefensive, aggressive type of undertaking, perhaps best categorized by the solid state physics-transistor-electronics communication revolution of the past one or two decades, overtly undertaken at great risk, but with greater possible return. Synthetic fabrics would fit this category, too. But I will not elaborate on these distinctions or get further involved in semantics.

It was suggested by this subcommittee in its invitation that I might have some ideas or observations. I would like to offer one specific suggestion, namely the deliberate development of techniques, curriculums, experiments, and even institutions to provide the Nation with many more effective people serving as "appliers of science."

Given the 15 years of intimate NSF-university relationship, the Foundation might well be the logical national instrument to bring this desired objective into being. Or the independent research institutes could make a considerable contribution out of their long and proven experience in this art of applying science.

Why the emphasis on "appliers of science and technology"? These are the persons who, when properly selected for motivation and when skillfully and purposefully trained (and surely in a multidisciplined way, involving science, engineering, economics, sociology, communications, for example) under practical conditions, would help materially to identify and solve some of the problems relating technology and economic growth discussed by many for the past half dozen years.

My point concerning "appliers of science" would not be at variance with Dr. Teller's earlier statement to this committee that the U.S. effort needs more attention to applied science, and particularly at the graduate level where so much of our effort is now related to pure science. The emphasis seems to be totally on producing Ph. D's, most of whom neither possess nor are they taught entrepreneurial skills. It should be noted that basic research not infrequently emerges from the needs of applied science, as well as the other way around, as is usually expected. And I would add to this that even in the graduate schools

of engineering, this predominantly basic approach seems more controlling than ever, despite our apparent dependence upon engineers as "doers" and as couplers between science and the economy.

Many informed people have stated that the impact of technology on economic growth in this country is not as great as it would first appear or as would be implicitly expected. Many of the reasons for this are obvious and have to do with the basic mission orientation of the bulk of our national research effort. But there are other more subtle reasons, some of which were dealt with very well in the Weinberg report of the President's Science Advisory Committee (officially titled "Science, Government and Information," and dated Jan. 10, 1963). This report, a landmark in the field of information transfer, has as one of its key points the need to distinguish between the transfer of documents, the problem receiving the most attention, and the actual transfer of scientific and technical information. Much would be gained if all graduate students in science, engineering and in business were to study and act upon this terse and important work. One of its key statements is: "Transfer of information is an inseparable part of research and development. All those concerned with research and development—individual scientists and engineers, industrial and academic research establishments, technical societies, government agencies—must accept responsibility for the transfer of information in the same degree and spirit that they accept responsibility for research and development itself." This matter of the literature is only one of the dimensions of the great need for perhaps a new profession—"the application of science."

The utility of science and its resulting technology lies in what can be done with it to expand corporate profits, Government mission capabilities, or regional and national economic growth. Over the past 10 years, a tremendous amount of potentially useful information about science and technology has been generated in this country. Yet we are all concerned about whether we are making adequate use of it for economic growth. Here we have a significant challenge which "appliers of science" could undertake and attempt to understand.

Another set of problems which "appliers of science" could handle is implicit in the obstacles to the fruitful uses of technology, such as the lack of management insight about markets required for the results of research; the unwillingness of some corporate managements to take appropriate risks, which could render existing plant or organization obsolete. As MRI's technology utilization work for NASA has so clearly demonstrated, there is much greater industrial interest in new materials, new processes, new production techniques, because these will require only incremental changes, whereas new products per se could frequently involve greater marketing risks and new plant investments.

Many scientifically trained people are primarily career oriented, seek individual recognition by their peers, with discovery of new knowledge as a principal end in itself. As a consequence, many are unable to fulfill their personal goals within the corporate goal framework.

An "applier of science," knowing that management goals and views are measured by profits and competitive position, would be capable of communicating his findings in the context of their economic utility

(the decisions to use technology, in industry, are largely economic, not technical).

An "applier of science" would help overcome other resistance points to using new technology; old-fashioned building codes being one example; the resistance of some labor groups to automation being another.

He would know that often technology is transferred indirectly, such as by the chemical industry invading the textile industry with its new synthetic fibers.

Specific curriculums directed to the "application of science" might help to bring about a more fruitful rapport between universities and industry, now limited by the unwillingness of some university people to relate their research or academic programs to economic and industrial needs. As these "appliers of science" become more numerous and more skilled, the geographic separation of industry and universities, which is considerable in many parts of the country, would be a less formidable barrier to economic growth than it now is.

I am suggesting that, if NSF is to expand its university programs, it should induce a new dimension of attitude and substance in the university curriculum, which will arouse expectations emphasizing goals and values among scientists and engineers that are consistent with the realities of corporate life and not, as is often the case, that corporate life will be an extension of their graduate school experience. The inclusion in this type of program of more professors with industrial backgrounds would result in younger scientists and engineers developing better insights about the role they will play as employees in industry, and perhaps in public agencies, as well. Some top-flight schools are now underway in such efforts, such as the Sloan School at MIT.

There could be developed, for example, techniques for retraining the technical man, 10 or 15 years out of school, who has already demonstrated entrepreneurial ability, but he may need to be reeducated in his field so he has something to entrepreneur with. The medical profession has done this job very well, as have many graduate business schools.

Internships in the hard sciences and engineering would be very valuable, if they included heavy doses of attention to technical motivation and the economic realism so essential to the success of technology.

Another approach might involve a new use for the sabbatical year by people whose career commitment is to generate knowledge through basic research. Perhaps a year at the transfer points of knowledge would enhance things immeasureably. "Appliers of science" would constitute a sort of impedance match to join the world of today with the academic system.

It will not be easy to find either the right faculty or the right students to develop "appliers of science," or even the right communications mechanisms to bring this about. These people will need training in sociology, anthropology, economics, communications skills. They will have to be trained differently than they are now, with much greater emphasis on bringing technology to more fruitful use.

It may be that graduate business or enginering schools would be most appropriate for starting this sort of effort. Or as a more modest

beginning, special summer institutes for university personnel, including selected graduate students, would be useful, especially if the "faculty" were experienced industrial people.

With today's shortage of skilled people, the Nation can benefit from an intelligent division of labor. In the context of applying science for economic growth, the research institutes might well have a clearly definable role in which they have comparative advantages, being well equipped as knowledge transformers, as I have outlined. Often new knowledge requires years or even decades before it is put to economic use. Transformation of knowledge can often be more effective economically and more capable of acceleration than creation de novo.

We probably don't have time to get into two other issues that are related here: One is the need for better technology in certain backward businesses such as textiles, construction, metalworking, where the appliers I have described would be of far more help than they would be in advanced industries; and the second point, which has been discussed in other hearings, but has a generic relationship here, is the geographical distribution of R. & D. and the effect of NSF on that.

That concludes my statement, Mr. Chairman.

Mr. DADDARIO. Thank you, Dr. Kimball.

You feel that NSF in the future should be active in the transfer of knowledge. Would you recommend that NSF should not confine itself as much as it does to basic research?

Dr. KIMBALL. The simple recommendation I am making here, sir, is this: The transfer of knowledge so far has been carried on by people who seem to have special aptitudes on it on somewhat of an ad hoc basis. I don't know that anybody has been trained to do it particularly because it is too recent an episode in the American scene. I am suggesting that if NSF wishes to extend its activities outside basic research in the universities, it might well foster some intensive training of people to be competent "appliers of science."

Mr. DADDARIO. You also indicate that even though there are reasons for basic research to create knowledge for itself alone, that there is a stimulus that comes to the basic researcher by being involved with some goal, and that he ought not to be removed from that opportunity.

Dr. KIMBALL. Right.

Mr. DADDARIO. Since this is the case and since there should be this energizing, the National Science Foundation should not overlook this possibility.

Dr. KIMBALL. There is much value to having basic research people exposed to applied research people as frequently as possible. I tried to make the point that much basic research stems from the fact that certain applied research problems cannot be solved. So we have to go back to the basic research foundation to get it.

Mr. DADDARIO. What has been your experience that leads you to believe that there ought to be a retraining of people every so often? As I have discussed this with people in industry, there seems to be a tendency for their researchers when they get out of school for the first 2 years to have a tremendous drive toward basic research. After this period, they see that they may be of more value to themselves as well as to their work by correlating it with applied science. Is this included in your recommendation?

Dr. KIMBALL. Yes; and carrying your point further, the people who are beyond the new worker category in research, spending more of their time on applied research, I think they will be better applied researchers if they can get some retreading, 6 or 10 years out of what is new in basic activities. The splendid analogy, of course, is the doctor of medicine, who goes back for the refresher courses for a few weeks every few years, and in a very condensed fashion he learns what is new in medicine. This could well be accomplished by NSF, for example, another kind of special institute, bringing people particularly out of industry and applied research where they may not be adequately exposed to basic research. Now, you can read all about this, you don't have to go back to school, but as I tried to point out with respect to the plethora of information that is published today, a person can't possibly do it himself, it has to be distilled.

Mr. DADDARIO. Part of the barrier seems to be that some of our people develop the idea that the field of the greatest prestige is basic research. Your suggestion seems to be a method toward breaking down this barrier.

Dr. KIMBALL. But for another reason, too. Most of the basic research in the country is funded by the U.S. Government, approximately 60 percent. This brings many of the younger scientists just out of graduate school into working only on public problems. Possibly one of the reasons that technology is making no greater contributions to economic growth is that many of our more proficient scientists are not working on private problems; that is, corporate problems.

Mr. DADDARIO. I was intrigued by the contribution that the nonprofit research institutes have had in the regions where they are located. I would imagine that you have been able to do this because people have wanted positive results from you and you have been able to achieve that end. At the same time, you have built up a field of experience which has been helpful to the Nation.

You have said that we would not have time here to get into the area of geographic distribution. Had you planned to discuss your experience that has shown by directing your efforts with the proper kind of people toward the transfer of knowledge in certain areas of the country you have been able to stimulate activity there, energize the development of programs, and fill in gaps?

Dr. KIMBALL. Yes; and I think it has also demonstrated the close coupling between technology and corporate economic growth. On the issue of research and development distribution as a function of geography, bearing on your point, I would recommend serious attention to emerging centers of competence which are not yet to critical mass. Some very sagacious public funding, not too much in any instance, could be most useful in their full development.

A classical example is the Menninger Foundation at Topeka, Kans., one of the leading psychiatric research and treatment groups in the world, funded largely by private contributions but appreciably enhanced in recent years by the activities of such Federal agencies as the National Institute of Mental Health. This is one example of a private and public funding. There are others throughout the country in other fields which could emerge as well.

I was quoted in Science this week as stating that the part of the country I come from is not too well off economically, and therefore it would get along a lot better if it had more public funding. The quotation of mine was taken out of context, and is something of an oversimplification. The point is that a little Federal leverage could enable many competent groups, whether they are colleges, universities, research institutes or other institutional forms, achieve this critical point of operation.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I have a technical question I would like to ask. I am curious to know who owns the title to such organizations as your own?

Dr. KIMBALL. They are public corporations under section 501(c) (3) of the Internal Revenue Code. No individual or group of individuals has or can have a personal proprietary interest in the assets of the corporation. The governing board is usually a group of trustees.

Mr. VIVIAN. Similar to most foundations?

Dr. KIMBALL. Yes, sir.

Mr. VIVIAN. Suppose you wanted to sell the organization, who would then possess the proceeds, presumably the board itself?

Dr. KIMBALL. No; not as individuals. The organization's charter usually provides for diverting the funds to some other public purpose. If the charter is silent, general principles of law reach the same results.

Mr. VIVIAN. Are there any provisions on the sale?

Dr. KIMBALL. Our charter says that if we were to cease operation the proceeds would then be given to a community trust, which again would be another form of tax-exempt organization.

Mr. VIVIAN. To switch back to your relationship with NSF for a few moments, I gather you foresee very little future in your relationship to NSF since you do not mention any particular role?

Dr. KIMBALL. The research institutes and NSF could have a more fruitful relationship than they have had. We have all recognized that NSF has had its hands full in trying to do a rather excellent job with the universities. In the case of some of the smaller institutes, grants for specialized scientific equipment, such as have gone to universities, would have been quite helpful through the years. If NSF gets into the field of encouraging applied science and educating "Appliers of Science," it might well look to the research institutes who have been doing this very effectively for a number of years.

Mr. VIVIAN. For example, you wouldn't mind receiving contracts to provide the framework of education for the career industrial system that you feel is left out at present?

Dr. KIMBALL. Yes. I look at this more as a national problem rather than something that the research institutes are seeking in a new role with NSF. I am just trying to call to the attention of the committee the fact that this problem has to be faced. Whether it is going to be faced by the universities operating under NSF, or the universities operating some other educational activity, is an issue that is perhaps beyond these hearings, but it is a compelling issue in the country.

Mr. VIVIAN. Would you construe your relationship as being much closer to the Department of Commerce if it establishes more aggressive economic development operations than the sciences?

Dr. KIMBALL. Yes; I am quite familiar with what they are doing over there, and I think it is a good thing. The State Technical Services Act I believe will help, although that is oriented largely toward universities.

Mr. VIVIAN. As I recollect, there is no major not-for-profit research institute in the Boston area. Am I correct?

Dr. KIMBALL. There is a very large highly competent and well run institution known as A. D. Little, which is not a not-for-profit organization.

Mr. VIVIAN. I recollect that is a for-profit organization.

Dr. KIMBALL. Yes; and very successful.

Mr. VIVIAN. Stanford has SRI.

How about Los Angeles?

Dr. KIMBALL. SRI has a southern branch at Los Angeles.

Mr. VIVIAN. Is it of any consequence or size?

Dr. KIMBALL. I would think, sir, 200 or 300 people.

Mr. VIVIAN. I note these organizations only because they are in the areas which have grown very rapidly technically. By comparison I note, for example, that Cornell Aero, which I believe is not-for-profit organization such as yours, MRI, and others have not seen the very rapid expansion around their borders which these other communities reflect. I don't think this is the fault of your not-for-profit institutions in any sense, I wouldn't want to construe that. But if you have concentrated heavily on the economic applications of technology, which I think most institutes have done, why has this not reflected in a greater expansion in the surrounding communities?

Dr. KIMBALL. I could cite the case of Kansas City which I know best. When MRI was founded 20 years ago the total technical complement in Greater Kansas City, scientists, engineers, economists, and the like, was approximately 500 people, and today it is approximately 7,500 people. And the institute has been responsible in stimulating much of that growth.

Mr. VIVIAN. So you argue that the success has been very significant even though not perhaps as obvious?

Dr. KIMBALL. Yes. A part of this is the project work institutes do. Another major role is the climate of understanding which institutes set up, as a result of their many public service activities, among community leaders, who have taken many decisive actions.

Mr. VIVIAN. Do you see any reasonable split between the functions of the National Science Foundation and the functions of the Department of Commerce? Do you see any lack of clarity in that split?

Dr. KIMBALL. I don't know NSF as well as I know Commerce, but if I had to make a summary statement about NSF, and it won't be entirely accurate, it would be that it is virtually totally academically oriented and basic research oriented.

Mr. DADDARIO. Will you yield there?

Mr. VIVIAN. Yes.

Mr. DADDARIO. In your relations with the Commerce Department, you have mentioned Dr. Holloman, whom we know very well. Do you see a proper coordination of activities between the Department of Commerce and the National Science Foundation so that there is effective communication and coordination of activities?

Dr. KIMBALL. I am sure they should work with each other. The point I am trying to make here, sir, relates specifically to NSF in an expansion of its university programs. It is now concentrating largely on basic research in what are known as the hard sciences. If this "applier of science" concept is to take root, NSF might well direct its activity more in this direction, at least to a beginning degree, and sponsor educational activities of this sort in business and engineering schools. This would be a new role for NSF.

Mr. DADDARIO. Have you come to this conclusion because of the work you have done with the Commerce Department? Do you see a need for the type of people who could help the Commerce Department to accomplish these end objectives?

Dr. KIMBALL. Not only with Commerce, but with NASA, too, which is pretty deeply and effectively involved in technology utilization. I am trying to look ahead here, perhaps a whole generation, so that the type of people who are involved in this sort of work, 10 or 20 years hence, will be better trained for it.

Mr. DADDARIO. Mr. Brown?

Mr. BROWN. Dr. Kimball, in your statement you noted that possible reasons for the failure to achieve an adequate technology transfer in the area of new product development are the larger problem of rechanneling investment and a reluctance of industry to engage in a major shift of resources resulting from new product development. Could this be a possible factor in the situation in your own area, that there has been a reluctance to make new investment, whereas there is an industrial preference to invest in coastal areas where they might feel the opportunities are better?

Dr. KIMBALL. There is perhaps a higher degree of understanding in the coastal areas, about the venture capital needed that goes with technology. The point I was making earlier is that if we examine the transfer of information from public sources to private use, there is a greater tendency for companies to pick up and use ideas about new techniques, new ways of doing things, new ways of improving their present products and processes, as distinct from going into a whole new line of products, because of the obvious economic factors.

It is becoming quite clear there are many fruitful transfers of knowledge that are being picked up by industry, large and small, but they are principally of the new process, new technique category, rather than a whole new product. It is very difficult to find a product in the public sector that can be turned over intact in this way. The only major one I know that has been of any real consequence has been the jet engine which took 12 years to move from the public to the private sector; radar, for example, on which television depends to a large degree, was not moved from the public to the private sector in one package, rather the technology was moved.

Mr. BROWN. I have had a substantial interest in the technology utilization transfer problem. In conversations that I have had with private companies and entrepreneurs in my own area, there seems to be a difference of opinion as to the value of this, depending upon perhaps the size of the operation. Large corporations seem to be less interested in participating in a technology utilization program perhaps because they see less to gain from it than do small corpora-

tions which are really more adventuresome and are seeking new products or new methodologies. I don't know what the answer to this problem is. I don't know whether your company has had this experience or not.

Dr. KIMBALL. The larger companies practice technology transfer to a considerable degree, but they don't call it that. They have what I call technical intelligence agents working continuously screening and channeling vast amounts of technical information into their own organizations, whereas the smaller company is not able to do this to such a degree.

Mr. BROWN. I think that is correct. There has come to my attention recently what I consider to be an excellent example of technology transfer in an entrepreneural sense involving a cooperative relationship between a university in Los Angeles and a Brazilian university; utilizing personnel from both sources, they have moved into Brazil—and this has occurred in other parts of Latin America—with a program for developing new industry, new technology. This has been done with local private capital.

This program is necessary in an economically underdeveloped area, but equally necessary is a well delineated program that is technically adequate, that does a good job of market research and resources analysis success, and that works successfully in planning or developing economic operations within the framework of an entrepreneural or private enterprise system. Have the nonprofits had any experience with moving into other areas, other than the United States, where they could perform a service in a receptive atmosphere, and at the same time do so in accordance with the kind of economic system that we are interested in furthering?

Dr. KIMBALL. I think the principal practitioners of that sort of activity are Stanford Research and Battelle. Battelle, has two large laboratories in Europe, one in Frankfurt and one in Geneva, which do essentially no government research, either U.S. or foreign government. They are staffed and directed by citizens of those countries. At Stanford Research, some 30 percent of its total economic research activity is in the international field, much of it coupling technology and economic growth.

Mr. BROWN. I am interested in knowing more about a program that could be sponsored by our own Government—whether we call it basic research or not. One of the fundamental problems which confronts our society as a whole, is the economic development of underdeveloped areas, in a pattern or a climate which is favorable to our own system. This is the competition that we are experiencing in the rest of the world, and in which we haven't had a great deal of success. It could be construed as basic research, although not in the physical or the biological sciences, but basic social research to determine how this might be achieved most successfully.

Dr. KIMBALL. I might say we could afford to practice some of that in the United States, in certain parts of the country.

Mr. BROWN. We have underdeveloped parts of this country, too. The real problem does not differ at all in nature——

Dr. KIMBALL. But in degree.

Mr. BROWN. But in degree. I have no further questions.

Mr. VIVIAN. Since this question of moving from the international to the intranational scene has been mentioned, I would like to ask a few questions.

On a matter of regional distribution, do you have any comments on the overall subject of how regional distribution might be measured, determined or accomplished, recognizing the fact that, for example, your own portion of the Nation is not what we could call overendowed with the Federal research funds.

Dr. KIMBALL. Certain institutions in each part of the country, whether educational or other, ought to be singled out either for their proven or their potential competence. They ought to be given reasonable amounts of money, with specifically directed activities, and with cardinal points of accountability every few years. I would strongly suggest that the "competence" concept be implicit in all these. I might say parenthetically that not all the competence is on the east or west coast.

Mr. VIVIAN. Do you have any feeling for any criteria that might be applied, not necessarily in setting up the centers of intelligence, but in the award of the contracts?

Dr. KIMBALL. No; I hope it has dimensions other than political.

Mr. VIVIAN. Yes; do you have any suggestion for dimensions other than political?

Dr. KIMBALL. No.

Mr. VIVIAN. If you had to choose factors that were effective in attracting individuals to certain areas, how would you rank such factors as climate, facilities, cultural advantages, training, and technical activities? Which seem to be the most important?

Dr. KIMBALL. What we have done in Kansas City is to convince people, that had not been there, that it was neither an intellectually nor geographically arid zone. Once having done that, the movement began to proliferate itself and has continued.

Mr. VIVIAN. It wasn't a question of solely salaries?

Dr. KIMBALL. No.

Mr. VIVIAN. But it was establishing an environment where the person felt he would be with his peers?

Dr. KIMBALL. Right.

A Stanford research study shows that there was not a direct correlation or any appreciable correlation between the excellence of universities and the buildup you are speaking of. There is a correlation, but I don't think it is a cause-and-effect relationship.

Mr. DADDARIO. Just one question, Dr. Kimball.

When you indicated the effect your institute had in the Kansas City area, this is not to say that you do not do work throughout the rest of the country. The effectiveness of your institute would be in other places beyond your own region?

Dr. KIMBALL. Yes, sir. Only a small percentage of our total project activity is in the Kansas City area. Last year we worked for sponsors in some 35 States, for example.

Mr. DADDARIO. How has the growth come about in that particular area?

Dr. KIMBALL. It is not simply providing a research service to companies that need it. It is climate setting for the economic use of applied technology, which is implicit in much that I said here today, and in the public service role of MRI.

Mr. DADDARIO. Dr. Kimball, I want to thank you.

I hope that we may be able to send to you and to Dr. Weinberg some additional questions that we have. We are somewhat limited by time in the questioning.[1]

We want to thank both you and Dr. Weinberg for your excellent testimony this morning.

This committee will adjourn until Tuesday next, at 10 o'clock, at the same place.

(Whereupon, at 12:25 p.m., the committee was adjourned, to reconvene at 10 a.m., Tuesday, July 13, 1965.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

TUESDAY, JULY 13, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Our first witness this morning is Mr. Francis Keppel, Commissioner of Education.

We are very pleased to have you here, Mr. Keppel.

STATEMENT OF HON. FRANCIS KEPPEL, COMMISSIONER OF EDUCATION; ACCOMPANIED BY FRANCIS A. J. IANNI, ACTING ASSOCIATE COMMISSIONER FOR RESEARCH; HENDRIK D. GIDEONSE, PROGRAM DEVELOPMENT ADVISER, BUREAU OF RESEARCH; AND PRESTON VALIEN, DIRECTOR, PROGRAM SUPPORT BRANCH, DIVISION OF GRADUATE PROJECTS, BUREAU OF HIGHER EDUCATION

Mr. KEPPEL. Thank you, Mr. Chairman. May I introduce to the committee my associates? On my left, Mr. Ianni, whose particular concern has been the research and development programs of the Office of Education which have certain relations with the National Science Foundation; my associate, Mr. Gideonse, also associated with Mr. Ianni; and to my further right, Mr. Valien, who is with the higher education facilities fellowship programs. These are the parts of the Office which I think have the closest relationships with the National Science Foundation.

Mr. Chairman, I have a prepared statement which, if I may, I would like to read perhaps two-thirds of, but skip some of it in order to save the committee's time, if that is satisfactory.

Mr. DADDARIO. That is fine, Mr. Keppel.

(Hon. Francis Keppel's prepared statement is as shown below; his summarization follows:)

PREPARED STATEMENT OF HON. FRANCIS KEPPEL, COMMISSIONER OF EDUCATION

Mr. Chairman and members of the Subcommittee on Science, Research, and Development, it is a pleasure to appear before you today to offer any assistance that I can to your subcommittee's review of the National Science Foundation. May I state at the very outset that the relation between the Office of Education and the Foundation, Dr. Haworth and his colleagues, has become an increasingly close and mutually useful one. As time has passed, we have come to work together in several different areas. The nature of the relationships that have grown up vary all the way from statutory requirements, through ad hoc commit-

tees, to close, informal contacts between officials responsible for administering individual programs in areas of joint responsibility. Wherever the need for cooperation and consultation has arisen, we have found the Foundation a willing partner.

One of the most useful things I think I can do would be to review some of the substantive areas in which the Foundation and the Office of Education have mutual responsibilties, describe what OE's activities are, and outline formal and informal mechanisms of cooperation between the two agencies. There are four areas that should be of particular interest to this subcommittee. I shall discuss each in turn and conclude my testimony with some brief comments on, as you put it in your invitation, Mr. Chairman, some problem areas with which the subcommittee might wish to concern itself.

One of the major areas of mutual responsibility between the National Science Foundation and the Office of Education is support for the construction of graduate facilities in institutions of higher education. The Higher Education Facilities Act of 1963, which the Office of Education administers, provides grants and loans for both graduate and undergraduate facilities in colleges and universities throughout the country. Under title I of the act, grants to 4-year undergraduate institutions are limited to the support of facilities devoted to science, mathematics, modern foreign languages, engineering, and libraries. Graduate facilities, however, may be supported in all fields except the medical sciences (which are already provided for by NIH), theology, and divinity. Buildings to which admission is charged may not be supported.

The undergraduate grants program is managed by State commissions which draw up State plans and make recommendations to the Commissioner of Education on the basis of those plans. Money is allotted to the States according to a formula based on per capita income and college-age population.

The purpose of the graduate grants program is to develop new centers of excellence in graduate studies to increase the number of highly qualified people who can fill the needs of the community in industry, government, teaching, and research.

Title II of the Higher Education Facilities Act has as its mission the improvement of existing graduate schools and assistance in the development of new and developing graduate schools. An important part of this program is the provision for cooperative graduate centers to permit universities to pool their resources for effective work in fields beyond the capability of any one institution.

The graduate grants program is managed by an advisory committee which consists of prominent educators together with one representative each from the National Science Foundation and the President's Science Advisory Committee. Under this program, no State may receive more than 12½ percent of the total appropriation for any one year. In the grants made last June, the Northeast received approximately 14 percent of the grants, the Atlantic coast (from New York to Florida) approximately 30 percent, the Midwest about 21 percent, and the Far West 14 percent. Grants have gone to large and small universities.

The Office of Education facilities program complements the National Science Foundation program. The NSF program is almost entirely concerned with research facilities, while the Office of Education program includes the support of facilities for both teaching and research. In the sciences a proposal not deemed suitable for a grant by NSF because of limited research space projected might be appropriate for a grant under the Higher Education Facilities Act. In general, the Foundation does not make grants for undergraduate facilities such as are provided under title I of the OE-administered Facilities Act.

To insure the exchange of information and a measure of coordination among various graduate facilities programs, the Office of Education this past February established an ad hoc committee with representatives from the Office, NIH, NSF, and NASA to meet once a month to discuss their programs and consider ways of complementing one another's efforts. I think we can show, both as a result of the statutory requirement for membership of an NSF representative on the Adivsory Committee and the activities of the ad hoc committee, that the cooperation on these types of programs has been extensive and productive for both our agencies.

Two major differences exist between the NSF and OE programs besides the Foundation's research emphasis. One is that NSF can make up to 50–50 matching grants based on eligible costs (this means that in fact NSF usually does not pay a full 50 percent of a given building's cost), while the OE grants are

limited to one-third of the eligible cost of the facility. This difference may result in some "shopping around" by universities seeking science facilities in an effort to get the most favorable terms. In view of the sharp enrollment increases in the Nation's colleges and universities, however, the administration is considering seeking a liberalization of the current matching requirement. This change would have the effect of bringing that requirement closer in line to NSF's present policy.

The second difference is that the higher education facilities program provides for other fields in addition to the sciences. Approximately 70 percent of the grants for graduate facilities have been in nonscience fields. This program is the only substantial Federal program providing nonscience facilities.

A second major area of mutual responsibility between our two agencies is the improvement of the qualifications of elementary- and secondary-school teachers. The Foundation's institute program, designed to supplement the training of elementary and secondary school teachers in science and mathematics, is of considerable magnitude. In fiscal 1964, 3,354 elementary school supervisors and teachers received training in 107 institutes. Inservice teachers training at the secondary level, however, represents the Foundation's largest single effort in support of science education. In fiscal year 1964 approximately 35,100 secondary-school teachers of science and mathematics received supplementary instruction as a result of grants for institutes and conferences.

The Office of Education institute programs, under the original NDEA, up to 1964 had served 20,000 elementary- and secondary-school teachers in 386 summer and academic year institutes in modern foreign languages. In December 1963, the Congress amended the act to include institutes for teachers of English to students whose native language is not English; two such institutes were held for the first time during the summer of 1964.

In October 1964, Congress amended NDEA and added a new title XI which authorized a far broader institute program. Under this new title the institutes in modern foreign languages and in English as a foreign language were continued, and seven new types of institutes were added: institutes for teachers of history, geography, reading, English, and of disadvantaged youth; school library personnel; and educational media specialists. The first institutes under this expanded authorization are being held this summer.

In every instance the deepening and broadening of teachers' competence in subject matter is to be emphasized. The act stipulates that the institutes shall be for "advanced study, including study in the use of new materials." Instruction is at the postbaccalaureate level and participants generally have met at least the minimal requirements for State certification. Institutes are also supposed to improve the teacher's instructional practices, and consequently the use of new teaching materials is encouraged. These include the use of new communications media as well as curriculum materials.

The Office of Education takes the initial step toward the establishment of institutes by inviting all eligible colleges and universities to register official interest in the program and to submit completed proposals. A printed guide, a copy of which I have available for the record, is sent to colleges and universities interested in preparing proposals.

Each proposal is read, evaluated, and rated by at least three members of various panels of consultants drawn from the relevant subject area or area of specialization and from all levels of American education. The primary criterion for support is the quality of the proposed program and the staff. The final decision with regard to any proposal, however, will depend partly on the location of the institution. In arranging a program to meet national needs, an attempt is made to insure that each section of the Nation receives adequate attention. Geographic location of the institution as well as the concentration of population in the region concerned are therefore taken into consideration. I have appended to my testimony a series of tables indicating the number of institutes proposed for 1965–66, the number approved, the different types of institutes, and their location by State. As a glance at the tables will show, the institutes are broadly distributed throughout the Nation.

In concluding my remarks on institutes, I want to emphasize that the Office of Education is operating under specific legislative authorization, and that while subject matter is emphasized, stress is also laid on the improvement of the teaching skills of participants with respect to the subject under study.

A third major area of mutual responsibility deals with graduate fellowship programs. Under the original provisions of title IV of NDEA, fellowship support was restricted to doctoral programs which were either new or expanded.

Between 1959–64, the 3-year fellowships were allocated to specific study programs. With only 1,500 new fellowships to distribute each year but with a growing number of qualified institutions and programs applying for them, competition became increasingly keen. The policy, therefore, was to shift support after 4 years to other new or expanded programs of promise and potential in order to distribute the available assistance as equitably as possible. It was never possible, however, to support all qualified programs or to give adequate support to the approved program.

Number of proposals received and number of institutes supported, title XI, National Defense Education Act, 1965–66, by area

Area	Number of proposals	Number of institutes
Teachers of:		
History	163	84
Geography	80	40
Reading	189	53
English	258	105
English as a foreign language	5	4
Modern foreign languages	141	83
Disadvantaged youth	139	63
School library personnel	58	26
Educational media specialists	105	36
Total	1, 138	494

FIGURE 1

Summary table of number of institutes and participants, title XI, National Defense Education Act, 1965–66, by area

Area	Number of institutes	Number of participants
Teachers of:		
History	84	3, 183
Geography	40	1, 493
Reading	53	2, 146
English	105	4, 480
English as a foreign language	4	220
Modern foreign languages	83	4, 156
Disadvantaged youth	63	2, 501
School library personnel	26	966
Educational media specialists	36	1, 375
Total	494	20, 520

FIGURE 2

Distribution of 494 title XI, National Defense Education Act institutes for advanced study, 1965–66, by area and State

	History	Geography	Reading	English	English, foreign language	Modern foreign language	Disadvantaged youth	Library	Educational media	Total
1. Alabama			1	1			1			3
2. Alaska	1			2		1				4
3. Arizona	1				1				1	3
4. Arkansas	2						1			3
5. California	3	3	2	9		9	9		2	37
6. Colorado	4		1	3		2		1	1	12
7. Connecticut	3		2			1	1		1	8
8. Delaware				1						1
9. District of Columbia	3		2	1		1	2	1		10
10. Florida	1	2	2	2		2	3			12
11. Georgia	2	1	1	3		1		1	1	10
12. Hawaii		1		1		1			1	4
13. Idaho	1	1								2
14. Illinois	2	4	1	6		3	2	2	3	23
15. Indiana	4	2	2	3		3	2	1	2	19
16. Iowa		1		2		1				4
17. Kansas	4	1	1	2		2	1	1	1	13
18. Kentucky	2	2	2	1		1		1		9
19. Louisiana	2	2	1	1				1		7
20. Maine				1		1	1			3
21. Maryland		2	1	1		1	4			9
22. Massachusetts	2	1	2	5		3	1	1	1	16
23. Michigan	3	2	2	6		1	1	1	1	17
24. Minnesota	1	1		6		2		1	1	12
25. Mississippi		1	2				1			4
26. Missouri	1	1		1		1	1			5
27. Montana						1	1			2
28. Nebraska	2		1	2			1		1	7
29. Nevada				1	1					2
30. New Hampshire	2					2	1		1	6
31. New Jersey	2	1		1		3	2			9
32. New Mexico				1		1				2
33. New York	3	1	3	5	2	9	9	3	4	39
34. North Carolina	3	1				2	2	1	2	11
35. North Dakota				1					1	2
36. Ohio	3	1	2	2		3	4	1	3	19
37. Oklahoma	1		1	3		1		2	1	9
38. Oregon	3	1	1	2		3		1	1	12
39. Pennsylvania	5		3	4		4	1		1	18
40. Rhode Island			2				1			3
41. South Carolina	2		1	2		2				7
42. South Dakota	1		1							2
43. Tennessee	3	2	2	1		1		1	1	11
44. Texas	4	1	3	11		4	2	3	1	21

Distribution of 494 title XI, National Defense Education Act institutes for advanced study, 1965–66, by area and State—Continued

	History	Geography	Reading	English	English, foreign language	Modern foreign language	Disadvantaged youth	Library	Educational media	Total
45. Utah	1			1		1	1			4
46. Vermont	1			1		1				3
47. Virginia	2		3	2		2	2		1	12
48. Washington	2			2		2	1	1		8
49. West Virginia			1			1				2
50. Wisconsin	1	3	2	2		1	3	1	1	14
51. Wyoming			1	1		1				3
52. Guam				1						1
53. Puerto Rico	1		1	1	1		1			5
54. Virgin Islands		1							1	2
Total	84	40	53	105	5	82	63	26	36	494

FIGURE 3

The emphasis of the title IV program came to rest mainly upon graduate departments at developing institutions which could qualify in the new or expanding category, and upon expanding departments and new interdepartmental programs at established universities. Moreover, the act stipulated that fellowship allocations be made exclusively on the basis of programs which were devoted to preparing college teachers and which were approved by the Commissioner of Education. This concern with programs rather than institutions tended to focus title IV attention at the departmental level, while the limited duration of support encouraged narrow rather than broad gage academic perspective and planning.

The 1964 amendment to the National Defense Education Act fundamentally altered this state of affairs in several ways:

1. The number of fellowships was doubled for 1965–66 (i.e., from 1,500 to 3,000), increased to 6,000 for 1966–67, and to 7,500 for each of the 2 following years (through 1968–69).

2. Awards vacated by the fellowship recipient (voluntarily or involuntarily) were to be made available to the institutions for reallocation for the remainder of the original period of the award.

3. Most important, half of the fellowships for fiscal year 1965, and two-thirds thereafter, were released for allocation to doctoral programs which were not necessarily new or expanded, but which had the capacity to enroll additional students with existing staff and facilities.

Provided with the legislative amendment extending through 1968–69 and a supplemental appropriation for 1965, the title IV program needed a new policy—both for the immediate distribution of the 1,500 additional awards in 1965–66, and for the amended fellowship program as a whole.

The policy recommendations approved by the title IV Advisory Committee provided that future support be allocated in concentrated blocs of fellowships. The fellowship blocs will be distributed not only to new or expanded programs, but will also be directed to fill unused capacity in programs of quality wherever they might exist. The shifting and limited support fixed upon individual study programs thus gave way to a policy promoting institutional perspective and integrity for a development of graduate education nationwide. The encouragement of academic excellence was a foremost consideration in these policy deliberations. It was affirmed that the primary field for expanding doctoral study lay among those institutions whose graduate schools have experienced relatively recent but dynamic development and had the basic quality, resources, and leadership to make significant strides toward major graduate school status.

Of the total 1,500 supplementary awards for 1965–66, 210 fellowships were distributed among the new or expanded programs which had been recipients of the original 1,500 awards in the regular competition during the summer of 1964. But with regard to the remaining 1,290 fellowships, highest priority was set on programs previously ineligible for support—those which were neither new nor expanded—but whose capacity for doctoral students was as yet unrealized. Moreover, in order to initiate the policy of bloc support, it was decided to allocate no fewer than 20 fellowships to each successful institution. This meant that no more than 64 institutions could receive additional support for 1965–66.

Applications were received from 156 institutions; only 44 were selected for support. For the first time, the competing universities were required to make a full statement of institutional plans toward expanding graduate programs over the next 5 years. It was incumbent upon them to show a clearly conceived institutional scheme for utilizing a large number of fellowships effectively.

No minimum allocation has been set in the competition now underway for 6,000 fellowships in 1966–67, but the policy of giving bloc support to institutions exhibiting the promise of excellence will be a foremost consideration. Primary attention will be directed to fostering the potential of universities whose dynamic character places them within reach of the first rank in the foreseeable future. Institutions of established and acknowledged distinction will be given reasonable assistance to expand to full capacity but will be assigned a secondary priority. Special priority is assigned to institutions whose application for support may be approved in toto, thereby rewarding the university whose own self-appraisal reveals the high quality of doctoral programs selected for inclusion in its proposal.

The integrated development of graduate study, based upon thoroughgoing and critical introspection on the part of the university, is the key objective of the expanded title IV program. The institutional allowance of $2,500 annually for each title IV fellow on campus may be utilized by the graduate dean or academic

vice president as an instrument of academic advance, to be invested in accordance with the stated objectives and aims of the university for development of its graduate study capability.

The Office of Education has pursued this policy deliberately in order to achieve two purposes through the development of a single program. Not only will the fellowships significantly increase the number of graduate students entering college teaching, but the institutional support that accompanies the fellowship award will be distributed in such a way as to strengthen graduate education across the Nation. For the use of the subcommittee, I have appended to my testimony tables showing the areas of fellowship award for fiscal 1965, and the regional and State distribution.

Allocation of 3,000 fellowships by academic field

	Number	Percent
Humanities	730	24
Education	210	7
Social sciences [1]	862	29
Subtotal	1,802	60
Biological sciences	381	13
Physical sciences	548	18
Engineering	269	9
Subtotal	1,198	40
Total	3,000	100

[1] Includes history whereas NSF does not. In past years, history fellowships have totaled about 12.5 percent of the total for social sciences.

FIGURE 4

Allocation of fellowships by States 1959–60 through 1965–66 to institutions

[Number of fellowships]

	1959–60	1960–61	1961–62	1962–63	1963–64	1964–65	1965–66
Alabama	19	25	28	27	23	23	27
Alaska					2	2	2
Arizona	17	26	28	30	29	28	51
Arkansas	13	22	14	11	5	3	8
California	75	110	99	95	97	113	235
Colorado	24	41	38	27	19	30	47
Connecticut	16	18	20	15	19	26	49
Delaware	5	14	9	9	14	6	4
District of Columbia	23	31	19	20	22	26	28
Florida	31	28	33	30	34	38	44
Georgia	22	36	43	34	40	41	83
Hawaii	8	10	11	12	16	19	24
Idaho	15	17	12	9	4	1	6
Illinois	35	59	58	78	82	64	222
Indiana	34	55	42	48	50	44	137
Iowa	12	36	35	31	29	18	29
Kansas	22	29	36	28	38	36	56
Kentucky	15	13	10	14	13	15	10
Louisiana	27	45	29	28	37	33	52
Maine	10	4	7	5	9	3	2
Maryland	16	25	21	23	35	37	60
Massachusetts	30	46	56	51	57	84	195
Michigan	19	50	61	59	50	44	98
Minnesota	17	28	19	19	14	18	68
Mississippi	23	17	13	12	2	6	5
Missouri	28	46	49	45	48	47	126
Montana	11	13	9	14	12	11	12
Nebraska	9	16	15	16	13	12	8
Nevada				3	2	5	8
New Hampshire		3	6	9	9	7	10
New Jersey	12	24	24	28	25	32	48
New Mexico	13	13	11	8	5		6
New York	53	88	113	123	145	129	260
North Carolina	42	61	52	52	37	36	124
North Dakota	8	12	7	18	17	11	15
Ohio	14	42	45	55	75	70	96
Oklahoma	27	33	35	33	24	26	18
Oregon	26	43	41	36	38	33	80
Pennsylvania	34	60	58	58	56	55	153
Rhode Island	10	27	31	27	29	29	56
South Carolina	10	12	16	14	14	13	17
South Dakota	4	3	3	5	5	9	15
Tennessee	39	48	61	49	45	42	49
Texas	36	62	51	67	56	51	110
Utah	18	14	13	22	19	27	27
Vermont	3	3	5	3	5	1	4
Virginia	28	26	33	36	24	35	57
Washington	28	34	27	21	31	18	71
West Virginia	5	5	11	8	9	8	9
Wisconsin	5	19	31	24	12	24	77
Wyoming	9	8	10	11	5	11	2
Puerto Rico			2				
Total	1,000	1,500	1,500	1,500	1,500	1,500	3,000

FIGURE 5

1962–63 doctorates, 1965–66 title IV fellowships, and 1960 population percentages by geographic region

	Percent of 1960 population	Number of doctorates earned, 1962–63		Number of 1965–66 title IV fellowships	
			Percent		*Percent*
Office of Education regions	100	12,820		3,000	
1. New England	6	1,334	10	316	11
2. Mideast	21	3,059	24	553	18
3. Great Lakes	20	3,297	26	630	21
4. Plains	9	1,167	9	317	11
5. Southeast	22	1,210	10	485	16
6. Southwest	8	668	5	185	6
7. Rocky Mountains	2	404	3	94	3
8. Far West	12	1,681	13	420	14

NOTE.—In regions awarding relatively few doctorates, support from the title IV program has been high in proportion to their actual doctoral production. In the past 6 years, the single region that has received more title IV fellowships than any other is the Southeast, with 2,331 awards or 20 percent of all the fellowships. In recent years this region has awarded less than 10 percent of the Nation's doctorates. If it is assumed that low doctoral production is an indication of a shortage of facilities for graduate study, the strongest relative impact of title IV assistance is in those geographic regions where the shortage of facilities is the greatest.

In the Mideast and New England, heavy doctorate producing areas, title IV awards have gone, for the most part, to the newer or less prestigious graduate schools. In New England, for example, approximately half of the fellowships have gone to schools outside Boston, Providence, and New Haven. In Massachusetts, 75 percent of the awards have gone to schools that are not members of the Association of Graduate Schools. In New York, approximately half of the fellowships have gone to such schools.

FIGURE 6

Coordination with NSF on the fellowship program has been informal rather than official, but OE programs do operate with considerable knowledge of counterpart efforts at NSF. As a matter of fact, several of the Office officials have actually worked in the NSF programs. In addition, frequent informal meetings have been held between the staffs of the fellowship programs and, when the Office of Education panelists were briefed on the new policy, NSF officials responsible for training programs were present at the meeting. When the fellowship program changed its emphasis to long-range planning in the interest of strengthening graduate education, Office of Education officials consulted with their counterparts in NSF responsible for the science development program which bears, of course, some strong similarity to the new aims of OE's fellowship program.

The final area of mutual responsibility arises from the several pieces of legislation authorizing the Office of Education to conduct research in education. Research programs are conducted in the following areas: (1) handicapped children and youth, (2) the teaching of modern foreign languages, (3) new educational media, (4) adult and vocational education, and (5) cooperative research which is conducted by all parts of the education community and which researches problems generally in the field of education. The emphasis on research and development as a primary means to the achievement of quality education is only a few years old and it is in part to the Foundation's support of course content improvement efforts in the sciences that we owe the expansion of OE educational research activities.

We have been successful in involving individuals and institutions from every part of the educational and scientific community. The Office has supported 3,000 contracts and grants for research in education. These grants have gone to institutions and agencies in every State of the Union. The cooperative research program is the largest and most extensive of the Office's research programs. While the other research programs are directed to specific problem areas within education, for example, vocational education, cooperative research is authorized to conduct research, surveys, and demonstrations in the entire field of education. Its procedures may be taken as typical of other OE research programs.

Research proposals are forwarded for review to appropriate panels of research scholars. These reviewers evaluate the proposal according to the following criteria: (1) the potential significance of the proposed project for education; (2) the soundness of the research design or operational plan; (3) the competence and availability of personnel and facilities to carry out the proposed project; and (4) the economic efficiency of the proposed project. If a sufficient

number of field reviewers approve the project and give it a high priority, it is forwarded to the Research Advisory Council. The Research Advisory Council is composed of distinguished people drawn from all parts of the educational community who consult with, and advise the Commissioner on, the conduct of the entire research effort of the Office of Education. Proposals which meet the standards of this dual review are recommended to the Commissioner for award.

Generally speaking, the burden of identifying areas in need of research and development rests with individuals and institutions who request support from the USOT. Through this combination of individual and independent initiative and careful reviewing procedures, research has been supported in many fields within education. Basic and applied research studies have included controlled experimental research, surveys, correlational, methodological, and case studies, and developmental, and historical studies. Among the variety of educational topics covered are mental retardation, child development, aptitudes, and abilities, cognitive studies, educational psychology, cultural deprivation, the roles of teachers and school administrators, the development of language and reading skills, programed instruction, guidance and counseling, and school finance. We have also provided support for basic research in the behavioral and social sciences.

One major effort of the cooperative research program is its curriculum improvement program. A project in this program may deal with a curriculum, a course, a subject, or any aspect of these. It may cover any subject field at one or more grades or levels of education from preschool through higher and adult education. The curriculum improvement program of the Office represents an attempt to approach this area as an integrated whole. The Office is also conscious of the need to relate its curriculum improvement projects to other efforts in the field both up and down the grade levels and across the related disciplines. For these reasons, the Office attempts to identify and then to stimulate projects to fill gaps which may be created by the development of specialized courses or curriculums or to provide alternatives to already existing curriculum improvement efforts.

In order to insure that the efforts of the Office of Education and the National Science Foundation in the curriculum area complement each other, several coordinating practices are in effect. Cooperation has been institutionalized by the appointment of an NSF staff member to the OE curriculum improvement review panel since the initiation of the curriculum improvement program. NSF and OE staff members have conducted joint site visits to investigate the research potential of proposed project locations. The Office and NSF jointly review and fund proposals which relate to both agencies.

These, then, are the major areas of mutual responsibility: the construction of graduate facilities in institutions of higher education; fellowships for future college teachers; teacher institute programs; and certain kinds of research in education. I have tried to demonstrate the effectiveness and importance of the coordination that we have been able to achieve between the two agencies. Your invitation to testify also requested that I address myself to a discussion of areas where it might be desirable to consider in greater detail the nature of the relationship between NSF and OE programs.

In addition to some differences already discussed, questions ought to be raised about the efforts to improve school curriculums through the support of course content improvement projects under NSF and curriculum improvement projects under cooperative research in OE. As both agencies continue to undertake this kind of activity in different disciplines, it will be necessary to oversee cooperatively activities along the whole range of curriculum improvement to insure the preservation of pluralistic, diverse, and multiple approaches to curriculum and the enhancement of the spirit of experimentation at the local level. Increasing attention will have to be paid to the problem of how schools will "mix and match," if you will, the various courses being developed and indeed whether or not this is possible at all. Coordination of Federal activities in support of curriculum improvement is necessary to assure the continued existence of alternative choices for local policy planners without at the same time fomenting curricular anarchy in the Nation's schools.

A second question, closely related to the last one, involves the relationships between NSF and OE institute programs and between both and the curriculum improvement programs. It is well established that to be truly effective teachers must be trained in the use as well as renewed with regard to the content of the new curriculum materials. Both NSF and OE now operate major institute programs. As curriculum improvement efforts become more sophisticated, better efforts will have to be made to insure that teachers are able to adopt varieties of

new practices, and adapt their teaching to fit the needs of children moving from school to school and program to program. Little attention has been paid to this need in its larger ramifications, and although some NSF institutes have paid attention to the problems of teaching the new content, the NDEA institutes have perhaps more consistently concerned themselves with the teaching of the subject while continuing to place major emphasis on the subject matter itself.

Before completing this testimony, I would like to reiterate my earlier statements of appreciation for the amount and kind of assistance and cooperation we have received from the Foundation. It has in many ways made our task easier and contributed to the improvement of both our programs. Thank you.

Mr. KEPPEL. I am sure you realize it is a great pleasure to appear before you today. I would like to state at the very outset that the relation between the Office of Education and the NSF, Dr. Haworth and all his colleagues, has been increasingly close and useful. I might say I have been on my job for 2½ years, and this relationship has become more constant and intimate, formal and informal, every month.

The nature of the relationships that have grown up vary all the way from statutory requirements, through ad hoc committees, to close, informal contacts between officials responsible for administering individual programs in areas of joint responsibility. Wherever the need for cooperation and consultation has arisen, we have found the Foundation a willing partner.

Mr. DADDARIO. Will you discuss how these informal contacts work? During these hearings, we have had some discussion concerning the importance of such things as picking up the telephone.

Mr. KEPPEL. I will touch on it later program by program, sir, but not quite in the way you asked the question. Let me see if I can give some examples in the last month which, if I may say so, were not connected with these hearings. The Office of Education is undergoing a substantial reorganization because of its very rapid growth in the last 2½ years, and just yesterday, as part of a regular program that Dr. Haworth and I have, one of my colleagues and I went over to review the administrative changes with Dr. Haworth and his colleague with respect to why this change took place or another change took place. I think this is about the third or fourth routine meeting. Second, there is an informal interchange on advisory committees, which apply to some programs, but where it is not statutory, Mr. Chairman, we in effect accomplish the same thing in my office by asking an NSF staff member to attend the appropriate meeting even though it may not be in the statutes of our law and vice versa.

Finally, you indicated an interest in the kind of telephoning that goes on. Mr. Ianni could indicate that our office as a matter of pure routine whenever a proposal comes in in the mathematics or science area, a new curriculum or a program that affects so-called educational research, it is just routinely sent off for comment to NSF. I don't think it requires your action?

Mr. IANNI. No, it goes over.

Mr. GIDEONSE. And we receive from them proposals in geography, sociology, and so forth routinely.

Mr. DADDARIO. Who initiates that? Does it have to be cleared at various levels?

Mr. IANNI. No. Actually when the proposals come in, if they are in areas of concern to the Science Foundation they are automatically sent over by our proposal receiving unit in the office.

Mr. KEPPEL. I may say, sir, that both with Dr. Waterman and Dr. Haworth I have asked this point. We concluded that the best way to have this done was to have it routinely done, not going up to the front office in either case.

Mr. DADDARIO. Do people on the same level of activity and working in the same area get together and eliminate whatever problems there might be or do they ask for advice in regard to problems?

Mr. KEPPEL. This is the informal part which from my point of view is the most important. I would like to make this public statement now. The Office of Education when it came to new curriculums and a good many of the teacher training institutes and that sort of thing had a lot to learn from NSF. In effect it sounds like the Office of Education had to learn about education from the National Science Foundation. If that is what it sounds like, that is what I mean, Mr. Chairman. We could learn a lot from NSF on institutes, how to handle fellowships, Ph. D. fellowships, how to handle the program that Mr. Ianni is particularly concerned with on new curriculums. This was the kind of exchange that was more on our side, more to our benefit in the last few years than it was to NSF's, frankly.

I think, Mr. Chairman, there are four areas that would be of particular interest to the subcommittee. If I may just turn to each one in turn and then following your request, Mr. Chairman, point to certain problem areas, I believe is the phrase you used, with which you might wish to concern yourselves. One of the major areas of mutual responsibility between the two agencies is support for the construction of graduate facilities in institutions of higher education. The Higher Education Facilities Act of 1963 which the Office of Education administers provides grants and loans for both graduate and undergraduate facilities in colleges and universities throughout the country. Under title I of the act, grants to 4-year undergraduate institutions are limited to the support of facilities devoted to science, mathematics, modern foreign languages, engineering, and libraries. Graduate facilities, however, may be supported in all fields except the medical sciences—which are already provided for by NIH—theology, and divinity. Buildings to which admission is charged may not be supported.

That means stadiums and that sort of thing.

The undergraduate grants program is managed by State commissions which draw up State plans and make recommendations to the Commissioner of Education on the basis of those plans.

If I may say so, that means that the State commissions are the ones that are setting the priorities as to which institution gets the matching grant. Money is allotted to the States according to a formula based on per capita income and college-age population.

The purpose of the graduate grants program is to develop new centers of excellence in graduate studies to increase the number of highly qualified people who can fill the needs of the community in industry, government, teaching, and research.

That is almost a quote from the act, sir.

Title II of the Higher Education Facilities Act has as its mission the improvement of existing graduate schools and assistance in the development of new and developing graduate schools. To give you a sense of the order of magnitude, title I for grants is $230 million.

That is the undergraduate physical expansion. Title II, which is the graduate, is $60 million. In addition to this, you have a loan fund, which is title III, of $169 million. This is the order of magnitude, Mr. Chairman, that we are dealing with annually. One important part of the title II, the graduate program, is the provision for cooperative graduate centers to permit universities to pool their resources for effective work in fields beyond the capability of any one institution.

The graduate grants program is managed by an advisory committee which consists of prominent educators together, and here we get to statutory relationships with NSF, with one representative each from the National Science Foundation and the President's Science Advisory Committee. Under this program no State may receive more than 12½ percent of the total appropriation for any 1 year. In the grants made last June, the Northeast received approximately 14 percent of the grants, the Atlantic coast—from New York to Florida—approximately 30 percent, the Midwest about 21 percent, and the Far West 14 percent. Grants have gone to large and small universities.

As you can see, Mr. Chairman, this has only been going on since the appropriation was received this fall.

This program I think it is fair to say complements the NSF program. The NSF program is almost entirely concerned with research facilities, while the Office of Education program includes the support of facilities for both teaching and research. In the sciences a proposal not deemed suitable for a grant by NSF because of limited research space projected might be appropriate for a grant under the Higher Education Facilities Act. In general, the Foundation does not make grants for undergraduate facilities such as are provided under title I of the OE-administered Facilities Act.

To insure the exchange of information and a measure of coordination among various graduate facilities programs, the Office of Education this past February established—this is another type of relationship, an ad hoc committee, this is not by statute—with representatives from the Office, NIH, NSF, and NASA to meet once a month to discuss their programs and consider ways of complementing one another's efforts. I think we can show, both as a result of the statutory requirement for membership of an NSF representative on the Advisory Committee and the activities of the ad hoc committee, that the cooperation on these types of programs has been extensive and productive for both our agencies.

Two major differences exist between the NSF and OE programs besides the Foundation's research emphasis. One is that NSF can make up to 50–50 matching grants based on eligible costs. I may say, sir, I understand from Dr. Haworth that NSF does not pay a full 50 percent of the amount of a building's cost. That is with relation to what you describe as eligible, what is an eligible cost under the NSF. In any case it can make up 50–50 grants, while the Office of Education grants are limited to one-third.

In view of the sharp enrollment increases in the Nation's colleges and universities, however, the administration is considering seeking a liberalization of the current matching requirement. This change would have the effect of bringing that requirement closer in line to NSF's present policy.

I understand what that verb means, "shopping around" in Washington. I don't know that it means any harm.

Mr. DADDARIO. You mean it is done on occasion?

Mr. KEPPEL. I think so. I sometimes thought that academic freedom rested between Government agencies. In view of the sharp enrollment increases in the Nation's colleges and universities, however, the administration is considering seeking a liberalization of the current matching requirement. This change would have the effect of bringing that requirement closer in line to NSF's present policy.

Mr. DADDARIO. You have raised the point that NSF does not pay up to the full 50 percent and have referred to the one-third as not being enough. Is it your policy to use the entire one-third in each instance?

Mr. KEPPEL. It is actually not within our power, sir. The State commissions have the power to decide within the State the extent to which the Federal funds shall be used for matching, that is, the language of the act reads up to one-third, in a good many of the States, I have forgotten how many, say up to 25 percent, they have so many applications, they have decided that the matching funds are available to institutions within the State, and they can spread the expansion program.

Mr. DADDARIO. You have no control whatsoever with reference to their discussion as to the amounts of money that may be used up to two-thirds?

Mr. KEPPEL. They send us in a plan for carrying out the act of Congress. We review the plan and the criteria. If those plans and criteria, which might well include in some States, I am not saying 33⅓ but up to 25, but if it meets the act, we approve the plan, and then the individual decision, institution by institution, are made by the State commission. And there we are in effect just routine, we don't question that.

Mr. DADDARIO. If the one-third should be increased to 50 percent, would that same condition apply, that it would be their prerogative rather than yours?

Mr. KEPPEL. That, of course, would depend, Mr. Chairman, on what the Congress wished to do with the language. I think we would recommend that the Congress consider language up to 50 percent rather than a flat amount.

Mr. DADDARIO. Up to 50 with certain additional powers in your hands?

Mr. KEPPEL. I don't think we have been thinking of that, sir, it is the first time I believe in higher education that the State commission technique has ever been used, and while I can't pretend to be an expert on it, Mr. Valien knows much more than I, I think it is working remarkably well. Rigidity in matching has shown itself in one example to be an unhappy circumstance. In the Higher Educational Facilities Act, part of the act refers to junior colleges or community colleges and requires that the matching be a flat 40 percent. The intent of Congress was clearly to encourage the development of junior colleges. Perhaps Mr. Brown will recall this. It was to give you a break. Well, the way it actually worked out in California and a couple of other States, the 40 percent, instead of freeing the prisoner locked him up tighter, if I can put it that way, because it had to be

40 percent and the nature of the proposals that came in were such that it ended up, for reasons that will take me perhaps too long to explain, with only one institution getting the support when there are a lot more asking. The State commission pleaded with us to give them flexibility, to reduce it from 40 to 30, which by law we could not.

Mr. MOSHER. It seems to me, in our State that this discretionary authority would be very valuable and very important.

Mr. KEPPEL. We would plead for it. In fact, we are going up to plead for discretionary authority up to 40 percent by amendment in the junior colleges.

Mr. DADDARIO. Your recommendation then supports the procedure but asks for more flexibility.

Mr. KEPPEL. Let me call it "technical amendment" at this point. I think that is what we are asking for, in public junior colleges.

Mr. ROUSH. Mr. Chairman, when the State commissions ask for matching funds only up to, say, 25 percent, is this caused by a limitation on funds or is it caused by limitations of authority?

Mr. KEPPEL. Funds, sir.

Mr. ROUSH. Wouldn't the first step then be to increase the amount of funds available rather than to increase the percentage of matching authority?

Mr. KEPPEL. I will feel better qualified to answer this very shrewd question, Mr. Chairman, after more experience. We have had one go around with the States since it has been in effect since November. What you are speaking to is really what is available in matching, either State money or private money. I am not sure I can answer that question well. Actually, the House subcommittee has proposed, and has now I believe waiting before the Rules Committee, very nearly a doubling I believe of the undergraduate figure on the assumption that there is that much matching. Obviously, my hopes are with it, but I would feel better, sir, answering that question a little later.

Mr. ROUSH. That is all, Mr. Chairman.

Mr. KEPPEL. The second difference in this higher education facilities program, other than the 50–50 matching, is, of course, that this higher education facilities program provides for other fields in addition to the science. You might be interested that approximately 70 percent of the grants for graduate facilities since it was funded 8 or 9 months ago have been in nonscience fields. This program I may say is the only substantial facilities Federal program provided in the nonscience fields.

A second major area of mutual responsibility with NSF is the improvement of the qualifications of elementary and secondary school teachers. You may recall, Mr. Chairman, I mentioned what the Office of Education had learned from NSF with respect to their institutes for such teachers in other fields. The NSF institutes program is designed to supplement the training of elementary and secondary school teachers in science and mathematics and is of course a big program. In fiscal 1964, 3,354 elementary school supervisors and teachers received training in 107 institutes. Inservice teacher training at the secondary level, however, represents the Foundation's largest single effort in support of science education. In fiscal year 1964 approximately 35,100 secondary school teachers of science and mathematics

received supplementary instruction as a result of grants for institutes and conferences.

The Office of Education institute programs under the original NDEA up to 1964 had served 20,000 elementary and secondary school teachers in 386 summer and academic year institutes in modern foreign languages. This was the original focus of the NDEA in teacher training.

In December 1963, the Congress amended the act to include institutes for teachers of English to students whose native language is not English; two such institutes were held for the first time during the summer of 1964.

In October 1964, Congress amended NDEA and added a new title XI which authorized a far broader institute program. Under this new title the institutes in modern foreign languages and in English as a foreign language were continued, and seven new types of institutes were added: institutes for teachers of history, geography, reading, English, and of disadvantaged youth; school library personnel; and educational media specialists. The first institutes under this expanded authorization are being held this summer.

Here I think the intent is close to the NSF intent, that is, the deepening and the broadening of the teachers' competency in the subject matter is to be emphasized. The act also stipulates that the institutes shall be for "advanced study, including study in the use of new materials."

An example might be in modern foreign languages—the new methods of teaching modern foreign languages with laboratories and that sort of thing.

Instruction is at the postbaccalaureate level and participants generally have met at least the minimal requirements for State certification. Institutes are also supposed to improve the teacher's instructional practices, and consequently the use of new teaching materials is encouraged. These include the use of new communications media as well as curriculum materials.

We go at this, I think, much the way NSF does. We invite all eligible colleagues and universities to register official interest in the program, and I have one of these documents for the committee's record in case the committee should be interested as to what is distributed to the colleges and universities to make such applications. And we follow, I suspect, a pattern not unlike the NSF's pattern. On the top of page 6 I go through the machinery here. I think the members of the committee, I am not sure how my testimony is before you, Mr. Chairman, but on mine at least immediately following this page on 6a and 6b there are some tables that show the number of proposals. As you can see from figure 1 (p. 298) we are forced to select a little less than half, can fund a little less than half of the proposals and figure 2 (p. 298) would show you the emphasis on the varying programs in history and geography. I would guess, sir, the only point where there might be a possible overlap, if that is the word, or relation with NSF would be under the heading of geography. That has been easy enough to work out. Finally, in figure 3 (p. 299) you will see the States in alphabetical order, and there have been these institutes. This is for the current academic year. We show they are scattered pretty widely across the country.

Mr. DAVIS. Dr. Keppel, I notice in figure 1 (p. 298), and in your testimony when you were referring to categories you start out with the well known subjects such as history, geography, reading, English, and then you say "disadvantaged youth." Does that mean that you study about disadvantaged youth?

Mr. KEPPEL. This, by the way, I think is a phrase taken directly out of the act that tells us to give institutes—the purpose here is the kind of teacher-training that one might give to a teacher who is going to be assigned to a slum school. This means really trying to teach them something about the motives, the homelife, the attitudes of children——

Mr. DAVIS. It is an orientation course?

Mr. KEPPEL. That, plus, I think, the psychologist and the sociologists—I had better turn to Mr. Ianni, whom I always tease about being wholly unable to understand the language of the social scientist.

Mr. DAVIS. He has plenty of company.

Mr. KEPPEL. I would say that the sociologist and the psychologist can give information to a future teacher as to what makes these students particular or not particular. These institutes are for that purpose.

Mr. DAVIS. That problem would no doubt vary in different parts of the country?

Mr. IANNI. Very much so. By the way, this is not restricted to social science, even in such areas as language; for example, there are specialized techniques which have to be used by children whose language background is not the same as the typical middle-class child.

Mr. KEPPEL. The third area of mutual responsibility deals with graduate fellowship programs. Each one providing the institution with $2,500 as well as the individual who won it.

That was established in 1958, got going in 1959 for the first time. The intent of Congress was very straightforward. It was fellowship support restricted to doctoral programs which were either new or expanded. The policy followed in order to keep spreading was to shift to a new institution in order to distribute the available assistance as equitably as possible. There were far more applicants than we could possibly fund.

Mr. ROUSH. I am not sure I quite understand the shift. The shift was from what to what?

Mr. KEPPEL. In a sense I haven't quite gotten to that. Let me come to that. The Congress in 1964 amended the NDEA fundamentally altering its program. There were three aspects to it that we should bring to your attention: No. 1, the number of fellowships to be awarded, assuming funding, was doubled; that is, it went from 1,500 in 1964–65 to 3,000 in 1965–66, and then for 1966–67 we are talking academic years here—from 3,000 to 6,000, and then 7,500. This means five times greater increase. That is change No. 1.

No. 2, any award vacated by a fellowship recipient was to be made available to its institution for reallocation.

No. 3, perhaps most important, the Congress decided that half of the fellowships for fiscal year 1965 and two-thirds after fiscal year 1965, that obviously is the coming fiscal year, were to be released for allocation to doctoral programs which were not necessarily new and

expanded but doctoral programs which had the capacity to enroll additional students with existing staff and facilities.

Clearly then the title IV program needed a new policy, both for the immediate distribution of 1,500 fellowships which we had already in hand last summer and the 1,500 new fellowships that were coming in as a result of a supplemental appropriation. What we did, Mr. Chairman, we had a statutory advisory committee, which we will be glad to enter into the record, whose advice the office sought as to what to do with shift in policy. In addition we asked a group of eminent university people and association people—let me just read a few names; Mr. Arlt, the president of the Council of Graduate Schools of the United States; President Brewster of Yale; President Harrington of the University of Wisconsin; including Dr. Riecken, the Associate Director of NSF as a member of that group, I can go on—to propose from the universities' point of view and NSF's and others what would be the most sensible program of carrying out this almost quantum increase. The recommendations of this group of university presidents were also reviewed by the statutory advisory committee and what I now speak to, sir, is the result of those steps. The policy recommendations by this group provide that future support of these Ph. D. fellowships be allocated in concentrated blocks of fellowships. The fellowship blocks will be distributed not only to new and expanded programs; that is the 1,500, but will also be directed to fill the unused capacity in programs of quality wherever they might exist. The shiftings and limited support fixed upon individual study programs thus gave way to a policy promoting institutional perspective and integrity for a development of graduate education nationwide. The encouragement of academic excellence was a foremost consideration in these policy deliberations. It was affirmed that the primary field for expanding doctoral study lay among those institutions whose graduate schools have experienced relatively recent but dynamic development and had the best quality, resources, and leadership to make significant strides toward major graduate school status.

Of the total 1,500 supplementary awards for 1965–66, 210 fellowships were distributed among the new or expanded programs which had been recipients of the original 1,500 awards in the regular competition during the summer of 1964. But with regard to the remaining 1,290 fellowships, highest priority was set on programs previously ineligible for support—those which were neither new nor expanded—but whose capacity for doctoral students was as yet unrealized. Moreover, in order to initiate the policy of block support, it was decided to allocate no fewer than 20 fellowships to each successful institution.

In thinking of this, Mr. Chairman, it might be not only worth thinking of those 20 Ph. D. candidates but also 20 times $2,500 or $50,000 to the institution.

Incidentally, this meant that no more than 64 institutions could have received additional support for 1965–66. Actually, 44 were selected. The institutions were asked to make a full statement of their institutional plans toward expanding graduate programs over the next 5 years. I emphasize this point because the program was initiated through collaboration with Mr. Riecken, who is very important at this point. In the academic year 1966–67 we will be entering into

a situation where we have not 3,000 but 6,000 fellowships. The policy of giving block support to institutions exhibiting promise of excellence will be of foremost attention. Primary attention will be directed to fostering the potential of universities whose dynamic character places them within reach of the first rank in the foreseeable future. Institutions of established and acknowledged distinction will be given reasonable assistance to expand to full capacity but will be assigned a secondary priority.

May I emphasize that, reasonable assistance is offered institutions to expand to full capacity because all of them are not necessarily to full capacity in all academic fields. Special priority is assigned to institutions whose application for support may be approved in toto, thereby rewarding the university whose own self-appraisal reveals the high quality of doctoral programs selected for inclusion in its proposal.

Mr. MOSHER. What criteria do you use to determine that a university exhibits the promise of excellence? Are these criteria largely subjective? How do you measure one State university against another State university neither of which has any great reputation? How do you determine which has more promise of excellence than the other?

Mr. KEPPEL. My understanding is that the graduate school or the institution submits a 5-year plan of how it wishes to develop department by department emphasizing those departments which in its judgment, humanities, social sciences, or sciences, are at the point where more graduate fellowships would help them to move. Now, these institutional proposals, include departmental statements by special fields. These are reviewed in two ways. The criterion I think inevitably is to a degree subjective, sir; it is based on the judgment of peers—that is, we ask reviewers to look over these documents in the academic specialty first. It is secondly reviewed as an institutional whole by the advisory committee whose membership I will put in the record, sir. So you get, as I understand it, both, a subjective estimate department by department and also probably an institutional estimate done by the overall advisory committee which adds up the departmental estimates, which is even more subjective, perhaps, but at least it is based on judgment of academic peers at the bottom of the judgment process.

Mr. MOSHER. At best, it must be a very difficult business?

Mr. KEPPEL. Oh, it is horrible.

Mr. MOSHER. Since your funds are limited, at best there must be some inequities resulting where you throw out one university and accept another which is in reality pretty much the same?

Mr. KEPPEL. Numerically, sir, here is what happened for the 3,000 size program: We had 150-odd institutional applications and only 44 were funded, and my correspondence has not been uninteresting.

Mr. MOSHER. In fact, I participated in some of it.

Mr. KEPPEL. I thought I would put that as delicately as I could. It will be very clearly different when we move from 3,000 to 6,000 where a much higher proportion can be funded. It is inevitably I suppose that way, sir. I just don't know how you can put numbers on some of these judgments. There is a consensus reached. It is astonishing how much it is reached on many of the departmental judgments and institutional judgments. Perhaps, Mr. Valien, you want to add to this?

Mr. VALIEN. I would like to say in terms of the objective information which we require, we attempt to get the listing of the faculty, frequently their contribution to the academic world in terms of research and in terms of production of students. We get also the resources of the university in terms of its endowment, in terms of its appropriation from the State legislature and from private foundations, its resources from other agencies of the Government who are also put into this equation, and the trend in its graduate enrollment. The trend in its doctorate enrollment is also studied to see if it is actually going up. We ask also the number of qualified applicants whom they had to turn down because of lack of adequate faculty or facilities. These are some of the objective emphasis which also go into the situation. Then, also, there is at least a limited period of experience which we have had. Some universities have not been able to use all the fellowships we have given them. That I think we would look at with a great deal of concern for applications of an increased number.

Mr. KEPPEL. In figures 4, 5, and 6 (pp. 302–304), we show the present state of distribution of this program. By academic fields, you may want to note, Mr. Chairman, and this statistic has been fairly steady for the last few years, 60 percent of these fellowships are in the humanities, education, and social sciences, and 40 percent in biological physical, and engineering. It has been holding at about that rate in recent years. And then a State-by-State distribution running back to the very first year of the NDEA program is shown in figure 5 (p. 303), starting with 1,000 the first year and then 1,500 and now 3,000 and showing the number of fellowships by State. And finally a kind of geographic breakdown on 9c (fig. 6, p. 304).

I think the committee may be more interested in the footnote than in any testimony. The footnote shows the relative distribution of these Ph. D. programs by regions, showing that relatively speaking we have very deliberately, because of the nature of the act put a higher proportion in, for example, the Southeast. A higher proportion of fellowships have gone there than the institutions in that part of the country contribute to the total college teacher population. Clearly the intent of the Congress was to strengthen those programs in the country or to help those which could establish new or expanded Ph. D. programs.

Mr. VALIEN. May I say that 20 percent of the total fellowships of 11,500 have gone to the Southeast, for example. That is the highest proportion of any region.

Mr. KEPPEL. This we understood to be the intent of Congress in this particular program. As you can see, sir, there is a breakdown as to percentages and numbers, and so forth, on 9c.

To go back, Mr. Chairman, to your earlier question, as to how this relation with NSF is carried out, on the top of page 10, I point out it has been informal rather than official. I think perhaps the word "statutory" would be better than the word "official" because it is official enough whenever we have a conference Mr. Riecken or somebody is automatically asked on the policy questions.

One way, of course, of doing this, sir, I am not sure that Dr. Haworth altogether appreciates this, is to go and raid his staff, so you have men on our staff who know the NSF procedures. And the informal meetings are of the sort we mentioned before. In the middle of page 10, sir, the final area of mutual responsibility arises from several pieces of legislation which authorize the Office of Education to conduct what is called "research in education." I list five of them—these are special acts of Congress, Mr. Chairman, special instructions, special authorizations—handicapped children, modern foreign languages, new educational media, adult and vocational education, where I think Mr. Brown will recall that in the Vocational Act 10 percent of the funds are set aside for research and development in the new Vocational Technical Education Act, so as the total appropriations of Congress go up in this act, the amount of such research automatically rises with it. Last year it was at the rate of $11½ million, this year $17 million, I think.

Finally, No. 5 is the so-called cooperative research program, the one that is now 10 years old, starting then at a million dollars, and now we seek before the Congress $25 million in the current fiscal year.

The program, as I suggest at the bottom of page 10 and the top of 11, has grown particularly in the last few years with 3,000 separate contracts and grants for research and institution and they have gone to every State of the Union. This cooperative research program is by far the largest, the most extensive, and covers the widest ground by statutory authorization of any of these research programs and is the one with which NSF has had the most relation, sir.

On the middle of page 11 I have set in my formal testimony the four criteria that are used by the reviewing process, significance, the research design, the competence of the staff and facilities, and let us call it the economic efficiency of the proposed project. We have the usual system, that I am sure the committee is familiar with, of field reviewers if it gets to a certain point. There is a research advisory council which we appoint, whose membership I would like to enter into the record, if I may, who look at the final proposals. We also have the names, sir, of the various members of the panels.

Mr. DADDARIO. I would appreciate in each case that you refer to a committee you would supply its membership, and that includes the ad hoc committees.

Mr. KEPPEL. Yes, sir.

(The information requested is as shown below. In addition, the membership of other advisory committees are contained in a publication of the Office of Education entitled "Public Advisory Committees," a copy of which may be found in the committee files.)

COOPERATIVE RESEARCH PROGRAM

RESEARCH ADVISORY COUNCIL

Dr. Fred C. Cole (chemical), president, Washington and Lee University, Lexington, Va.

Dr. G. Franklin Edwards,[1] professor of sociology, Howard University, Washington, D.C.

Dr. Albert H. Marckwardt, professor of English, Princeton University, Princeton, N.J.

Dr. Patrick Suppes, professor of philosophy, Stanford University, Stanford, Calif.

[1] Terminated June 30, 1965.

Vacant position.
Dr. Samuel M. Brownell,[1] superintendent of schools, Detroit, Mich.
Dr. Jacob Getzels, professor of psychology, University of Chicago, Chicago, Ill.
Dr. Thomas R. McConnell,[1] professor of higher education, University of California, Berkeley, Calif.
Dr. Alan T. Waterman, 5306 Carvel Road, Westmoreland Hills, Washington, D.C.

AD HOC BASIC READING RESEARCH PANEL

Dr. Harry Levin, Project Literacy, Cornell University, 320 Wait Avenue, Ithaca, N.Y. (chairman).
Dr. Jeanne Chall, Department of Psychology, City College of New York, New York, N.Y.
Dr. Theodore Clymer, College of Education, University of Minnesota, Minneapolis, Minn.
A. L. Danis, Department of English, Illinois Institute of Technology, Chicago, Ill.
Dr. Eugene Long, Department of Psychology, University of North Carolina, Chapel Hill, N.C.
Dr. Patrick Suppes, professor of philosophy, Stanford University, Stanford, Calif.
Vacant position.
Vacant position.

ARTS AND HUMANITIES PANEL

Dr. Allen Britton, School of Music, University of Michigan, Ann Arbor, Mich.
Dr. Gerald Else, Department of Classical Studies, University of Michigan, Ann Arbor, Mich.
Vacant position.
Vacant position.
Dr. Jerome Hauseman, School of Art, Ohio State University, Columbus, Ohio.
Dr. Maurice Mandelbaum, Department of Philosophy, Johns Hopkins University, Baltimore, Md.
Dr. Edgar Richardson, director, Henry Francis duPont Winterthur Museum, Winterthur, Del.
Vacant position.

CURRICULUM IMPROVEMENT PANEL

Dr. Lawrence Cremin,[2] Department of Social and Philosophical Foundations, Teachers College Columbia University, New York, N.Y.
Dr. Edward Mattil, Art Education Department, Pennsylvania State University, University Park, Pa.
Dr. Melvin M. Tumin, Department of Sociology, Green Hall, Princeton University, Princeton, N.J.
Vacant position.
Vacant position.
Dr. Ole Sand, director of instruction projects, National Education Association, 1201 16th Street NW., Washington, D.C.
Dr. Charles A. Whitmer, head, course content improvement program, National Science Foundation, Washington, D.C.
Vacant position.
Vacant position.

DEMONSTRATION PANEL

Dr. Henry M. Brickell, assistant superintendent, Manhasset Public Schools, Manhasset, N.Y.
Dr. Nathaniel Gage, Department of Psychology, Stanford University, Stanford, Calif.
Dr. Robert Glaser (chairman), 205B Mineral Industries Building, University of Pittsburgh, Pittsburgh, Pa.
Dr. J. Thomas Hastings, director, Center for Instructional Research and Curriculum Evaluation, University of Illinois, Urbana, Ill.
Dr. Russell Kropp, director, Institute of Human Learning, Florida State University, Tallahassee, Fla.

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[1] Terminated June 30, 1965.
[2] Dr. Cremin is on leave from the university and his address is: Center for Advanced Study in Behavioral Sciences, 202 Junipero Serra Boulevard, Stanford, Calif.

Dr. Harold Martin, director of general education, Harvard University, Cambridge, Mass.
Dr. Hollis A. Moore, Jr., W. K. Kellogg Foundation, 250 Champion Street, Battle Creek, Mich.
Dr. Wade Robinson, Associate Director, Office of Economic Opportunity, Brown Building, 19th and M Streets, NW., Washington, D.C.
Dr. Robert Travers, Department of Psychology, University of Utah, Salt Lake City, Utah.
Dr. Talman Van Arsdale, Jr., president, Bradley University, Peoria, Ill.

English Panel

Dr. John Carroll, Graduate School of Education, Harvard University, Cambridge, Mass. (chairman).
Dr. Robert Pooley, professor of English, University of Wisconsin, Madison, Wis.
Dr. Theodore Clymer, professor of education, University of Minnesota, Minneapolis, Minn.
Vacant position.
Vacant position.

Environment Panel

Dr. Roald Campbell, Graduate School of Education, University of Chicago, Chicago, Ill.
Dr. Theodore Newcomb,[1] Department of Social Psychology, University of Michigan, Ann Arbor, Mich.
Dr. William Sewell, Department of Sociology, University of Wisconsin, Madison, Wis.
Dr. Richard Snyder, Department of Political Science, Northwestern University, Evanston, Ill.
Dr. Anthony Wallace, Department of Anthropology, University of Pennsylvania, Philadelphia, Pa. (chairman).

Educational Processes Panel

Dr. J. Stanley Ahmann, head, Department of Psychology, Colorado State University, Fort Collins, Colo. (chairman).
Dr. Philip H. DuBois, professor of psychology, Washington University, St. Louis, Mo.
Dr. Daniel E. Griffiths, associate dean, School of Education, New York University, New York, N.Y.
Dr. Miriam L. Goldberg, associate professor of psychology and education, Horace-Mann Lincoln Institute of School Experimentation, Teachers College, Columbia University, New York, N.Y.
Hon. Byron W. Hansford, commissioner of education, State Department of Education, Denver, Colo.
Dr. Thomas Jordan, professor of education, Southern Illinois University, Carbondale, Ill.

Psychological Processes Panel

Dr. Kathryn Blake, College of Education, University of Georgia, Athens, Ga.
Dr. Royal Embree (chairman), professor of educational psychology, University of Texas, Austin, Tex.
Vacant position.
Dr. David G. Ryans, director, Bureau of Educational Research, University of Hawaii, Honolulu, Hawaii.
Dr. Robert L. Thorndike, professor of psychology, Teachers College, Columbia University, New York, N.Y.

Research and Development Centers Panel

Dr. Benjamin Bloom, Department of Education,[2] University of Chicago, Chicago, Ill.
Dr. Alan Pifer, vice president, Carnegie Corp., New York, N.Y.

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[1] Temporary address for Dr. Newcomb: Western Behavioral Sciences Institute, 1121 Torrey Pines Rd., La Jolla, Calif.
[2] Terminated June 30, 1965.

Dr. Ralph Tyler, director, Center for Advanced Study in the Behavioral Sciences, 202 Junipero Serra Boulevard, Stanford, Calif. (chairman).
Vacant position.
Vacant position.

AD HOC INTERAGENCY COMMITTEE

PARTICIPANTS

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- Dr. Henry W. Riecken, Associate Director, Education.
- Dr. Thomas W. Fontaine, Director, Division of Graduate Education Support.
- Dr. Howard E. Page, Director, Division of Institutional Programs.

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For the National Aeronautics and Space Administration:
- Dr. Thomas L. K. Smull, Director, Office of Grants and Research Contracts.

For the Atomic Energy Commission:
- Dr. Russell S. Poor, Director, Division of Nuclear Education and Training.
- Mr. George Courtney, Assistant to the Director for Plans and Programs.

For the Office of Education:
- Francis Keppel, U.S. Commissioner of Education.
- Peter P. Muirhead, Associate Commissioner for Higher Education.
- Dr. John W. Ashton, Director, Division of Graduate Programs.
- Dr. Kenneth W. Mildenberger, Director, Division of College and University Assistance.
- Dr. Alan D. Ferguson, Consultant, Program Support Branch.

Mr. KEPPEL. Generally speaking, the burden of identifying the areas of need for research and development rests with the individuals and the institutions that request the support from the Office of Education. Through this combination of individual and independent initiative and these reviewing procedures, research has been supported within many fields within education. That is we have had experimental surveys, correlation, the usual range that you would expect, sir. Among the variety of topics that are covered by these programs are mental retardation, child development, aptitudes and abilities. One study that has been of interest to the committee is one that focused upon a talented group of young high school graduates, beginning in 1960 and following them through college, to see where the loss of talent takes place. This may give the committee some background information about future leaders in the arts and sciences and so forth.

I list other types of areas on which we have invested funds for research. One of the major aspects of this program is the curriculum improvement program, and here we come closer still to the relation with NSF. In this area a project may deal with, let's say, a curriculum or a particular course or subject or any one of these. It may cover any subject field at one or more grade levels of education from preschool right through higher and adult education under the statute. The program of the Office represents an effort to approach this area as an integrated whole. It is obviously conscious of the need to relate its curriculum development projects to other efforts in the field both up and down the grade levels and across the related academic disciplines. For these reasons the Office tries to identify and then to stimulate projects to fill gaps which may be created by the development of specialized courses or curriculums or to provide alternatives to already existing curriculum improvement efforts.

May I emphasize that, to provide alternatives. My point is that the basic choice of curriculum now in this country rests with the local school board or the college, and in my judgment should. If the local school board or college is to have a real choice, to have a real decision to make about its content, its curriculum content, in our judgment there is a lot to be said for having several types of proposed new ideas, new curriculums available to them to make a choice. On that point the choice becomes real. This is in our judgment a way to be sure of the genuineness of school board and local school authority control over the curriculums. This is a policy which we have often discussed with the National Science Foundation. They are in a completely agreed upon joint policy.

Mr. DADDARIO. Do you bring this up to show the need of having within NSF and or within the Office of Education various alternatives rather than two agencies which might have different roads to travel?

Mr. KEPPEL. The second, sir, within each it seems to me. Obviously here, this curriculum development area, is an area in which there could be overlapping because of the broad authority given to the research program. In point of fact, we now are jointly financing with NSF. I think it is six programs in mathematics and science. Most of the curriculum development programs in mathematics and science are financed by NSF as is only reasonable and proper.

Mr. DADDARIO. If NSF was not involved in curriculum development, you would find that there would be alternatives as you probed into the subject matter yourself?

Mr. KEPPEL. Yes, sir.

Mr. DADDARIO. Your recommendation is that these alternatives are important and ought to be made available to the local school boards and the colleges as a guide, but only as a guide?

Mr. KEPPEL. That is much better stated than I stated it. That is exactly right. I think it is a very important public policy here that we are discussing here. The NSF itself established this policy it is fair to say before the Office of Education entered the curriculum development movement. We agreed with it, admired it and followed it.

Mr. DADDARIO. I bring it up because the point has been raised from time to time that one of the values of curriculum improvement comes from the fact that NSF and the Office of Education are separate agencies and as a result it opens up an opportunity for alternatives. You have added to this by showing that within each agency there ought to be no one approach, there should be a proliferation of approach rather than a condensation.

Mr. KEPPEL. Yes, sir; I agree.

Mr. GIDEONSE. We have two major projects, a series of projects actually. We call them Project English and Project Social Studies, but we deliberately went out and sought multiple approaches to curriculums in these areas. NSF has done the same thing in biology and chemistry. They deliberately set out doing three approaches to biology and two in chemistry so there would be alternative choices to the schools.

Mr. KEPPEL. I think, sir, it might be useful for the record if I were to say this, sir, with regard to these curriculum projects. There seems to be two reasons why the alternative or even competing approaches in English or history or something else are desired. No. 1, this

is the way to assure genuine decentralization, genuine choice at a local level rather than what could be an imposition of Washington's views. But, second, sir, we are a very long way in most of these subject fields from having the real confidence that such and such is the most efficient way to teach arithmetic or the most efficient way to teach English or a language.

Mr. GIDEONSE. I think we are more confident that there are many, many different ways to teach English and mathematics and social studies, and we ought to leave the choice as to which one to follow in a given case to the people who are really closest to the children or the teachers and the particular competencies or problems that a community may have.

Mr. DAVIS. I am really familiar with the education picture in only one State of the Union, and that is my native State of Georgia. Within the last decade the State has acquired the power to control the curriculum of a county or a city school board. However, it has exercised it only in the most gingerly way, and it may never exercise it very much. I would like to know if that is true in other States, or do you find that school districts are generally autonomous in this respect?

Mr. KEPPEL. There is a wide variation, sir, across the country. For example, by statute I would guess that the State of New York probably has potentially in the legal sense the greatest direct control over the curriculum. I am not sure of this, but I think that is true; whereas, you would find that some other State has in effect none. You get a variation here. In some cases the State legislatures have themselves, in effect, become curriculum committees and have instructed the schools to teach some subjects at a particular grade level, or a particular topic. Usually, however, such actions of the State legislature by statute are limited to a particular subject.

Mr. DAVIS. Such as the history of the State?

Mr. KEPPEL. Yes. In California recently the State legislature has instructed the schools to teach foreign languages when the children are young.

Mr. BROWN. The sixth grade. They are importing teachers from all over the country and outside the country.

Mr. KEPPEL. I have heard some complaints about that, Mr. Brown. You do get a varied picture. In most cases I think I would say that the State departments of education if they had the power, and this would be true in New York, have deliberately encouraged local judgment as a matter of policy. I would have to make a few exceptions perhaps, but the exceptions would be really exceptions and the majority would be acting I take it rather than the way that Mr. Purcell and his colleagues are in Georgia.

Mr. DAVIS. Thank you.

Mr. KEPPEL. At the bottom of page 12, Mr. Chairman, I refer to some of the methods we have been using for coordinating practices between the National Science Foundation and our office.

Cooperation has been institutionalized by the appointment of an NSF staff member to the OE Curriculum Improvement Review Panel since the initiation of the curriculum improvement program. NSF and OE staff members have conducted joint site visits to investigate

the research potential of proposed project locations. The Office and NSF jointly review and fund proposals which relate to both agencies.

These, then, are the major areas of mutual responsibility: the construction of graduate facilities in institutions of higher education; fellowships for future college teachers; teacher institute programs; and certain kinds of research in education. I have tried to demonstrate the effectiveness and importance of the coordination that we have been able to achieve between the two agencies. Your invitation to testify also requested that I address myself to a discussion of areas where it might be desirable to consider in greater detail the nature of the relationship between NSF and OE programs.

In addition to some differences already discussed, questions ought to be raised about the efforts to improve school curriculums through the support of course content improvement projects under NSF and curriculum improvement projects under Cooperative Research in OE. As both agencies continue to undertake this kind of activity in different disciplines, it will be necessary we suspect to oversee cooperatively activities along the whole range of curriculum improvement to insure the preservation of pluralistic, diverse, and multiple approaches to curriculum and the enhancement of the spirit of experimentation at the local level, which to NSF and the Office of Education seems very desirable. Increasing attention will have to be paid to the problem of how schools will "mix and match," if you will, the various courses being developed and indeed whether or not this is possible at all. Coordination of Federal activities in support of curriculum improvement is necessary to assure the continued existence of alternative choices for local policy planners without at the same time fomenting curricular anarchy in the Nation's schools.

A second question, closely related to the last one, involves the relationships between NSF and OE institute programs and between both and the curriculum improvement programs. It is well established that to be truly effective teachers must be trained in the use as well as renewed intellectually with regard to the content of the new curriculum materials. Both NSF and OE now operate major institute programs. As curriculum improvement efforts become more sophisticated, better efforts will have to be made to insure that teachers are able to adopt varieties of new practices, and adapt their teaching to fit the needs of children moving from school to school and program to program.

The Office of Education is relatively new at this enterprise in all fields except one. In modern foreign language it has had quite a lot of experience, but moving out of that field into English and history that we are now authorized in, we have had less experience in this than the National Science Foundation has had. Relatively little attention has been paid to this need in its larger ramifications, and although some NSF institutes have paid attention to the problems of teaching the new concept, the NDEA institutes have perhaps more consistently concerned themselves with the teaching of the subject while continuing to place major emphasis on the subject matter itself.

I am very grateful for your kindness in listening.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. I wanted to make an inquiry about some of the subject areas in this cooperative research activity. You have listed a number of items on page 12, which I don't think is an exhaustive

list. Have you engaged in any research projects involving some of the newer technology in educational TV? Have you been involved in some of these experiments where they have, for example in the Midwest, had the airborne TV or even satellite TV communication and its applications to various situations? Could this be funded under your cooperative research program?

Mr. IANNI. Actually we have a special program for that, the new educational media program which is also listed here. This specifically is designed to support research and demonstration in new techniques of education primarily using some of these new media. For example, we have supported some of the airborne television experimentation. We have done a considerable amount there in studying new ways of programing materials through the use of teaching machines and other devices of this sort, some of which has come along fairly well. For example, we have been experimenting with the development of new techniques for teaching the blind, and we have come up with a method that is actually four times faster than braille. Another technique which we have been experimenting with is teaching mentally retarded youngsters by the use of teaching machines and program devices. Here we have increased six times their ability to learn new words by using these techniques. I think it is fair to say that the whole idea of programing and computer instruction is very new and a great deal has to be done in the future on this.

Mr. BROWN. I am questioning the research, not the applicability of it. I am wondering whether the Office of Education is concerned with funding research or whether it is being funded in some other areas. For example, within the last few months it has come to my attention that a study in satellite education or educational TV used in satellites has gone to the AID because it has applications obviously in education of large underdeveloped areas. I would think that the development of programs in this area would have been tested perhaps in the United States, or that some research had been done in an area of this sort perhaps by the Office of Education. I recognize in a field which is changing as rapidly as this, it perhaps may not be desirable to try and put it into large-scale operation, but certainly there should be research on it.

Mr. IANNI. I would say this has been our principal approach. It is still highly experimental. We would be glad to supply for you a list of projects in this area to give you some idea of what is going on.

Mr. MILLER. Will the gentleman yield?

Mr. BROWN. Yes.

Mr. MILLER. What reports or results do you get from the system presently being used in Samoa?

Mr. IANNI. The new television technique there?

Mr. MILLER. Yes.

Mr. IANNI. Our experience has been that it is quite successful there. It is successful for some very specialized reasons. One is you have a very large area to cover, which is where educational TV tends to be most successful, and, second, that the level of education is low enough that you can use techniques for teaching reading, for example, and language instruction. Our experience has been that it is quite successful, and it could be used elsewhere.

Mr. MILLER. I visited Samoa with some members of the committee last year. We saw it being put into effect. I was struck with these youngsters learning the language. When we walked in behind them they didn't pay any attention to us. They were repeating after this voice, saying, "Yes," and they say "Yes." Since then I have seen an article that this system was more or less developed in Australia; is that correct?

Mr. IANNI. Actually in Australia, and I think ethnic chauvinism would lead me to also point out that it was developed in Italy. They have used it quite extensively there, particularly teaching in southern Italy with great success.

Mr. BROWN. Would you supply for the committee some information with regard to your research in these areas of program instruction, educational TV, satellite communication?

Mr. IANNI. Yes.

(In response to the above request, Mr. Keppel has submitted the following reports of the Office of Education, copies of which may be found in the committee files: "Cooperative Research Projects, a Seven-year Summary, July 1, 1956–June 30, 1963," OE12018; "Cooperative Research Projects Approved in Fiscal Year 1964," dated June 1964; and "Projects Initiated Under Title VII, Pt. A, National Defense Education Act, September 2, 1958–April 30, 1964," OE–34013–64.)

Mr. BROWN. I have a comment with regard to another area, the allocation of fellowships by academic fields. We have been questioning other witnesses in regard to the breakdown between the physical and biological sciences, and the social sciences. I notice in your table on page 9–A that the emphasis as far as your office is concerned is largely with the humanities and the social sciences—60 percent of the fellowships going to that area. This is a matter in which I think we need close coordination between the Office of Education and the National Science Foundation in order to get the proper balance throughout the various fields of activity.

Mr. KEPPEL. May I comment on this, Mr. Brown?

Mr. BROWN. Yes.

Mr. KEPPEL. To emphasize again, the intent of Congress with the NDEA Ph. D. fellowship program was aimed to increase the number of college teachers. The NSF's responsibilities are, of course, much broader than that for science as a whole. If you take a look at the academic role of higher education in general, something like 60–40 or 65–35 in there is the balance that exists between the number of college teachers in the humanities and the social sciences on the one hand, and the sciences on the other. We are, therefore, trying to keep the intent of Congress in mind in providing new people going into college teaching.

One other fact, Mr. Brown, might be relevant here. I don't have at my fingertips the statistics of the number of Ph. D.'s in the physical sciences, in the social sciences, and in the humanities who actually enter the academic world, but roughly speaking, because of the demands on scientists in the public section, you have a much smaller percentage entering college teaching. What we do is to ask those who take part in these programs to demonstrate intent to enter teaching. On the basis of what is admittedly inadequate evidence, Mr. Chairman, because this program only started in 1958—1959 really—

as you know, in theory you get a Ph. D. in 3 years; in fact, you are lucky if you get it in 6, so that we don't really have much evidence. You have to add 5 or 6 to 1959 and we get to where we are now, the holding power, which is my word for the intent of Congress to get into teaching, is well ahead of the average in all fields, humanities, of these NDEA fellows. Eighty percent are entering college. They show a difference of the intent of Congress between NSF on the one side and NDEA on the other.

Mr. DADDARIO. Do you have any questions, Mr. Miller?

Mr. MILLER. No. I am sorry I couldn't get here earlier because I am very much interested in what Dr. Keppel has to say. NASA is undertaking a fellowship program and we are not tying the students down by requiring that they go to work with NASA. We are trying to perhaps replace in the reservoir the people whom we drew out of it. How, as an educator, do you look at a program of this kind?

Mr. KEPPEL. I have talked a good deal with Dr. Simpson, who is leaving NASA to go to Georgia by the way, sir, and with Frank Hanson, who is perhaps more directly in charge of this. What NASA is doing makes a lot of sense to me. What I understand they are trying to do is to strengthen the infrastructure in those scientific areas which relate to NASA in a broad sense which would include from biology through to physics. In developing our program, Mr. Chairman, at the first basic conference for this expanded NDEA, Dr. Hanson was one of the members of the group who helped to bring this new program in. I think George Simpson reviewed it later. It makes sense to me, sir, and my guess is it will do exactly what Mr. Webb hopes it will do—namely, strengthen the overall space program which he knows very well will have to be strengthened in the university as part of their regular breath of life, as well as increase the numbers of people that NASA may need. I may say, Mr. Daddario, relations with the space agency are made infinitely simpler by the fact we are in the same building. All we have to do is go up a couple of floors.

Mr. MILLER. I think that is very fine that you should be in the same building.

Mr. KEPPEL. In view of our expansion, I sometimes think Mr. Webb is a little nervous, but not that nervous.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Mr. Keppel, I would like to thank you for the statistical detail in your statement. Following up on what Mr. Brown was asking, if you put all the various agencies and fellowship programs together, are we balancing the need and the supply in both the social sciences and the physical sciences for teachers? Are we meeting the need everywhere?

Mr. KEPPEL. I think I would have to say "No, sir"; that is, the rate of growth of higher education, particularly with respect to this generation that is just becoming 18 and 19 years of age is so dramatic that the colleges are having a tough time getting the quality staff they need. Now to break it down field by field, we do have some data on this, we have been making some analyses which we would be glad to furnish for the record if requested. Let me make just one general statement, Mr. Conable; may I? Those of us in my kind of work have been very worried for the last 10 years, roughly, at one statistic. What percentage of those taking full-time college teaching positions for the

first time have a Ph. D.? As you go back about a decade, I may be a little wrong in detail—if the chairman would forgive me, I would like to correct the record—the percentage of those entering colleges for the first time with a Ph. D. kept going down, down; we were going into the 30 percent and down in the twenties. I wouldn't say for a moment, sir, being my father's son, that it is a necessary instrument to get into Heaven, because he never had one and managed to make a career out of it, but, in fact, it is an index of the lack of supply of college teachers. Last year, for the first time, the percentage of men with Ph. D.'s entering college teaching for the first time, started going up. This is the first sort of hopeful sign. But it is very clear that there are particular fields in which the shortage is acute. Again to take a figure out of my memory, I think a year ago we had something like one-seventeenth of a new Ph. D. in mathematics per institution in higher education in the United States. The supply was that short.

Mr. CONABLE. If you had $100 million extra to put into graduate study, where would you put it? Would you put it all in the social sciences, or all in the physical sciences, or would you divide it in approximately the percentage in which it is being divided now considering all the agencies contributing to it?

Mr. KEPPEL. I won't say that this 60–40 we are using is right, but it is in the right ball park, sir.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I have a series of questions. Has our next witness arrived yet?

Mr. DADDARIO. Not as yet.

Mr. VIVIAN. A number of these questions will be connected, Mr. Keppel, with, as you point out, the rapid increase in new students. In fact I am startled every time I see those new statistics, and as I watch my own teenagers grow, I can understand why. They are phased in the curve long before we raise the revenue from their own efforts. We are building a new educational system. Certainly the change in the last 10 years is a totally new educational system. I think your research in education is one of the most fascinating parts of the whole story. I see it permeating into my own community. In this process, the respective roles of the Office of Education, NASA, NIH, and all the other agencies are becoming in my mind confused. I think it represents, in part, the fact that you are slowly shifting from a role of small participation, percentagewise, a participation which may be significant in a policy at a research level but not at a funding level to a situation which is becoming at least at the grade level a large involvement. It is no longer a policy of dearth; it is a policy of almost total support. With this, I think, the policy situation does have to change. Now, in terms of the total amount of funds expended, we have had some figures on science education as such and the involvement of the National Science Foundation. Do you have anything on the total amount of support provided by the Federal agencies, and the total support of science education in the United States?

Mr. KEPPEL. I don't know that the report that I have in my memory, Mr. Vivian, at this moment breaks it down quite that way. We have

gone through a summary; it is part of an interagency committee that was established, and we have been getting the raw data up, which I would like to enter into the record, if I may, sir.

This shows how the overall Federal funds are going. Let me give you an example of why I am not quite sure how to break down the figure. There is a figure in there of roughly $1 billion of what might be called vocational and technical education in the military establishment, I think that is roughly a billion. I don't quite know how to categorize that. Some of it might be reasonably called applied science and some of it perhaps should not be. I remember that particular figure as one. Perhaps we could enter this most usefully in the record, and I would be most delighted officially or personally to try to break it down further to get to the figure that your committee has in mind.

Mr. DADDARIO. It would be most helpful if you would.

(The information requested is as follows:)

FEDERAL FUNDS FOR EDUCATION AND TRAINING AND FOR SUPPORT OF ACADEMIC SCIENCE, FISCAL YEARS 1965 AND 1966

(U.S. Department of Health, Education, and Welfare, Office of Education, Office of Federal Education Activities, Federal Education Programs Branch, February 4, 1965)

Federal funds for education, fiscal years 1965 and 1966

[In thousands of dollars]

Type of support and academic level	Estimated obligations	
	1965	1966
Total	6,328,907	8,711,131
Elementary-secondary education	707,376	1,947,386
Support of local schools	609,205	1,631,906
Overseas schools	86,000	90,000
Supporting services	7,300	219,750
Other	4,871	5,730
Higher education	3,392,829	4,025,068
Research and development in colleges and universities	1,134,000	1,140,000
Facilities and equipment	996,781	1,195,028
Institutional grants	97,018	220,464
Fellowships and traineeships	182,252	233,038
Federal schools and training of personnel	427,417	463,554
Other student support	255,650	444,300
Training grants	299,711	328,684
Vocational-technical and adult education	2,058,194	2,553,431
Vocational-technical	1,949,681	2,404,690
Basic adult education	19,000	33,000
General adult education	89,513	115,741
Other education programs	170,508	185,246
Administration and services, OE and NSF	53,101	58,830
Library services	103,665	113,354
Educational television	13,742	13,062

Federal funds for education, fiscal years 1965 and 1966 [1]

[In thousands of dollars]

Program by type of support and academic level	Estimated obligations	
	1965	1966
Total	6,328,907	8,711,131
Elementary-secondary education [2]	707,376	1,947,386
Support of local schools	609,205	1,631,906
Federally impacted areas, OE	397,820	402,010
National Defense Education Act, OE	91,885	105,196
Proposed legislation, OE		1,000,000
Indian education, Interior	69,000	75,000
Shared revenues from public lands, Agriculture/Interior [3]	27,700	26,000
Other [4]	22,800	23,700
Oversea schools	86,000	90,000
Education of dependents of Federal personnel, DOD	72,000	75,000
Territories, dependencies [5]	14,000	15,000
Supporting services	7,300	219,750
Proposed legislation—supplementary centers, OE		100,000
Proposed legislation—library resources, instructional materials, OE		100,000
Proposed legislation—strengthening State services, OE		10,000
National Defense Education Act, State statistical services, OE	2,100	2,250
National Defense Education Act, State supervision and administration, OE	5,200	7,500
Other	4,871	5,730
Science education, NSF	3,800	4,600
American Printing House for the Blind, HEW	865	909
Kendall School, Gallaudet College, HEW	206	221
Higher Education	3,392,829	4,025,068
Research and development in colleges and universities [6]	1,134,000	1,140,000
Facilities and equipment	996,781	1,195,028
Higher Education Facilities Act, OE	463,150	641,750
Specialized research facilities support, NSF	26,700	31,500
Institutional science program, NSF	36,000	36,000
Nuclear training equipment, AEC	2,000	2,000
College housing loans, HHFA	277,000	312,300
Medical and health-related facilities, PHS	176,512	156,000
Gallaudet College, Howard University, HEW	2,177	3,228
Agricultural research facilities, Agriculture	3,242	2,000
Center for Cultural and Technical Interchange Between East and West, State		250
Specialized facilities, NASA	10,000	10,000
Institutional grants	97,018	220,464
Institutional grants, NSF	39,000	59,000
Specialized science education grants, NSF	1,450	2,500
Land-grant college instruction, OE	14,500	14,500
Language and area centers, OE	8,200	10,950
Handicapped program, OE	318	158
Health training, community health, PHS	12,100	13,800
Proposed grants to developing institutions, OE		30,000
Proposed library assistance, training, and research, OE		65,000
Teaching grants, vocational rehabilitation, VRA	8,230	9,518
Gallaudet College and Howard University, HEW	11,380	13,038
Center for Cultural and Technical Interchange Between East and West, State	1,840	2,000

See footnotes at end of table.

Federal funds for education, fiscal years 1965 and 1966 [1]—Continued

[In thousands of dollars]

Program by type of support and academic level	Estimated obligations 1965	Estimated obligations 1966
ellowships and traineeships	182,252	233,038
National Defense Education Act graduate, OE	32,740	58,108
Handicapped program, OE	8,915	12,818
Foreign language training program, OE	1,500	2,000
Public Health—community health, PHS	7,262	8,062
Public Health—environmental health, PHS	869	1,088
National Institutes of Health, PHS	48,172	54,580
Research fellowships and traineeships, vocational rehabilitation, VRA	11,580	12,782
Center for Cultural and Technical Interchange Between East and West, fellowships and grants, State	3,485	4,000
Nuclear fellowships and traineeships, AEC	2,329	2,400
Fisheries scientist fellowships, Interior	200	200
NASA traineeship program, NASA	25,000	30,000
Science fellowships and traineeships, NSF	40,200	47,000
Federal schools and training of personnel	427,417	463,554
Merchant Marine Academy, Commerce	3,567	3,644
Military academies, DOD	105,000	129,000
Coast Guard Academy and training of personnel, Treasury	11,850	12,910
Training of Federal employees	57,000	68,000
Training of military personnel, DOD	244,000	244,000
Special schools and courses, AEC	6,000	6,000
Other student support	255,650	444,300
Veterans education programs, VA	27,000	20,000
Work-study, Economic Opportunity Act, OE	56,000	84,000
Student loan program, National Defense Education Act, OE	146,700	181,550
Student loans, health professions, PHS	25,450	28,250
Proposed scholarships, OE		70,000
Proposed work-study program, OE		45,000
Proposed insured loan program, OE		15,000
Indian education, Interior	500	500
Training grants	299,711	328,684
Institutes for counseling personnel, OE	7,260	7,250
Institutes, NDEA, OE	21,413	31,640
Handicapped program, OE	5,269	6,523
Institutes and inservice training, civil rights, OE	6,000	6,300
Public Health—community health, PHS	15,333	12,729
Public health—environmental health, PHS	7,760	9,887
National Institutes of Health, PHS	180,527	193,396
Faculty training institutes, AEC	790	800
Institutes and other training grants, NSF	53,700	58,500
Child welfare training grants, WA	1,659	1,659
Vocational-technical and adult education	2,058,194	2,553,431
Vocational-technical training	1,949,681	2,404,690
Vocational education grants, OE	168,607	246,902
Manpower Development and Training Act training and subsistence, OE/Labor	342,640	386,361
Area Redevelopment Act training and subsistence, OE/Labor	8,229	(7)
Indian adult vocational training, Interior	12,205	14,427
Military technical, DOD [8]	1,050,000	1,093,000
Veterans education, VA	18,000	14,000
Office of Economic Opportunity programs, OEO/Labor/WA [9]	350,000	650,000
Basic adult education	19,000	33,000
Adult literacy program, Economic Opportunity Act, OE	19,000	33,000

See footnotes at end of table.

Federal funds for education, fiscal years 1965 and 1966 [1]—Continued

[In thousands of dollars]

Program by type of support and academic level	Estimated obligations	
	1965	1966
General adult education	89,513	115,741
Civil defense adult education, OE	4,006	4,006
Proposed urban community extension, OE		25,000
Agricultural extension service, Agriculture	85,107	86,335
Science education, NSF	400	400
Other education programs	170,508	185,246
Administration and services, OE and NSF [10]	53,101	58,830
Library services [11]	103,665	113,354
Educational television grants, OE	13,742	13,062

[1] Estimates from United States and agency budget documents. R. & D. estimates from National Science Foundation. Amounts for education estimated from larger budget entries in some cases. Excludes international education activities (see attachment I), school lunch program, and value of donated surplus property.
[2] Vocational education funds included in "Vocational-Technical and Adult Education" category.
[3] Estimated amount for schools from larger payments to States and counties.
[4] Includes estimated amount for schools from total Federal payment to District of Columbia and payments for Cuban refugee education.
[5] Estimate of Federal contributions for education from larger payments for support of public services.
[6] Includes R. & D. and curriculum development grants. R. & D. estimates from National Science Foundation.
[7] Program funds included in Manpower Development and Training Act entry.
[8] Estimated cost of military training programs exclusive of flight and recruit training. Higher education programs reported elsewhere.
[9] Preliminary estimate of amounts for education from community action, work experience, work training, and Job Corps programs. Part of the funds included support activities for preschool age children and basic adult education.
[10] Includes administrative costs, information services, and surveys and studies not reported in other categories.
[11] Includes grants to public libraries; operating expense of Library of Congress, Smithsonian Institution, National Library of Medicine, and National Agricultural Library; and depository library and catalogue and index activities of the Government Printing Office.

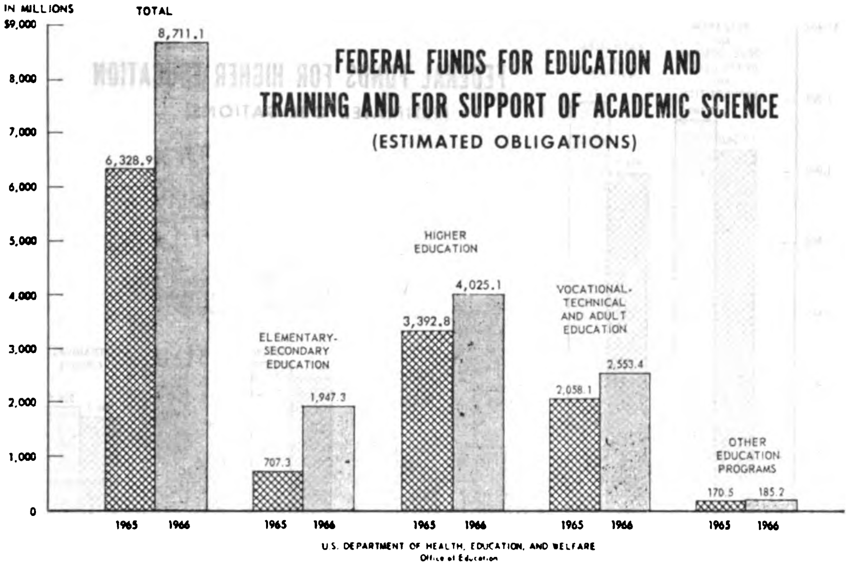
ATTACHMENT I

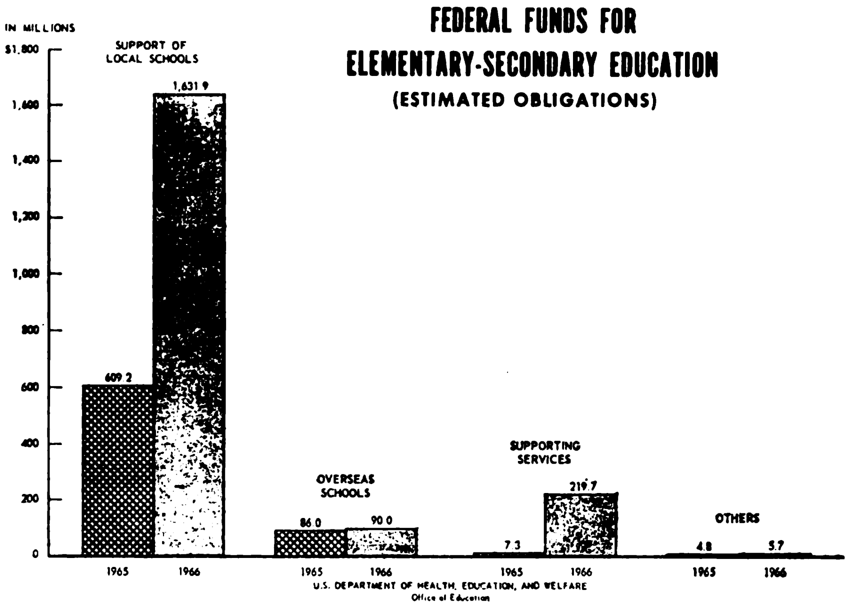
Federal funds for international education: Estimates for fiscal years 1965 and 1966 [1]

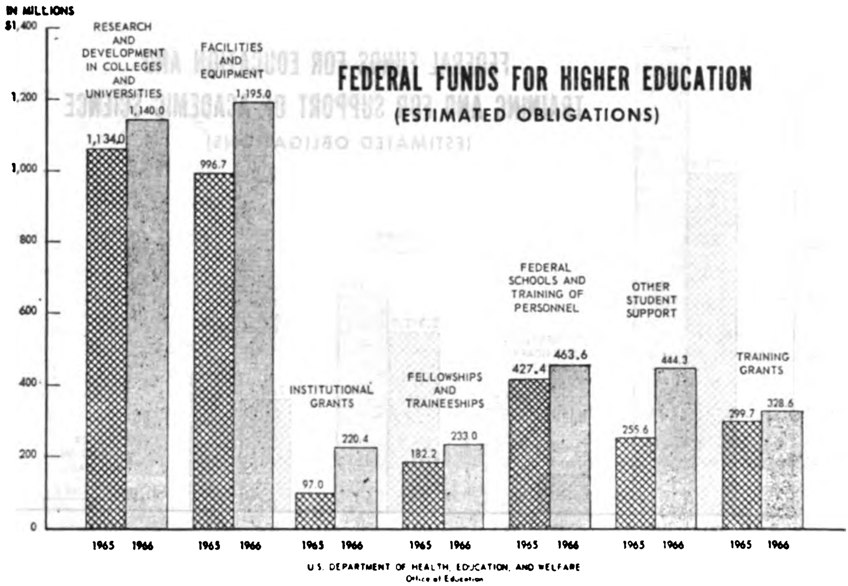
[In thousands of dollars]

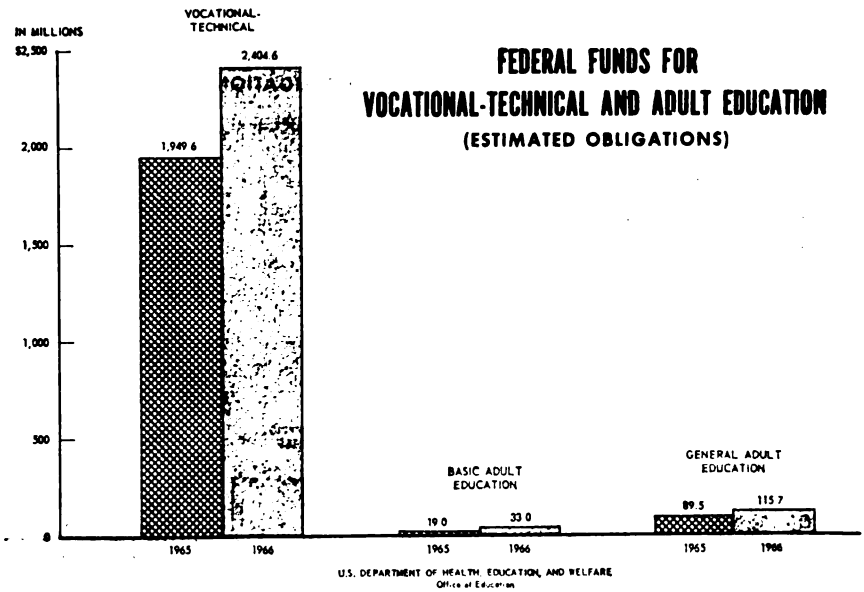
Program	Estimated obligations	
	1965	1966
Total	381,688	399,253
Educational exchange program, State	53,224	54,964
Peace Corps, volunteer and project costs	84,775	100,600
American sponsored and dependent schools abroad, AID [2]	27,000	27,000
Participant training, AID [2]	35,000	35,000
Education projects, AID [2]	84,600	84,600
Educational assistance, USIA [2]	89	89
Research and development in foreign institutions [3]	97,000	97,000

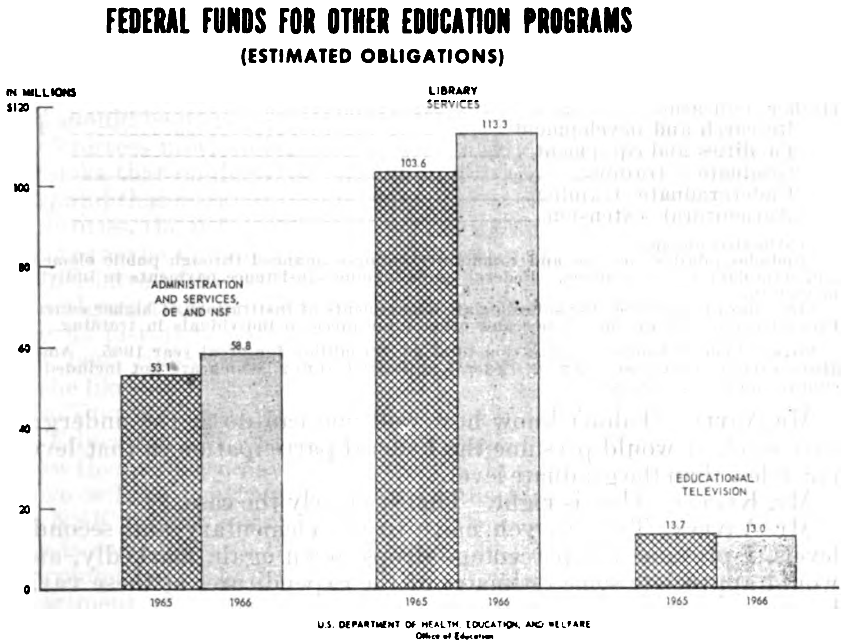
[1] Data incomplete. The Federal Government also supports education through contributions to international organizations. Assistance to foreign students under regular student support programs of the various agencies are not included in the data above.
[2] Estimates based on 1963 and 1964 data, as available from published reports or responses to the Office of Education surveys of Federal education activities.
[3] Based on latest published data of the National Science Foundation.


FEDERAL FUNDS FOR EDUCATION AND TRAINING AND FOR SUPPORT OF ACADEMIC SCIENCE
(ESTIMATED OBLIGATIONS)
IN MILLIONS
$9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
TOTAL
6,328.9
8,711.1
ELEMENTARY-SECONDARY EDUCATION
707.3
1,947.3
HIGHER EDUCATION
3,392.8
4,025.1
VOCATIONAL-TECHNICAL AND ADULT EDUCATION
2,058.1
2,553.4
OTHER EDUCATION PROGRAMS
170.5
185.2
1965
1966
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education


FEDERAL FUNDS FOR ELEMENTARY-SECONDARY EDUCATION
(ESTIMATED OBLIGATIONS)
IN MILLIONS
$1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
SUPPORT OF LOCAL SCHOOLS
609.2
1,631.9
OVERSEAS SCHOOLS
86.0
90.0
SUPPORTING SERVICES
7.3
219.7
OTHERS
4.8
5.7
1965
1966
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education


FEDERAL FUNDS FOR HIGHER EDUCATION
(ESTIMATED OBLIGATIONS)
IN MILLIONS
$1,400
1,200
1,000
800
600
400
200
0
RESEARCH AND DEVELOPMENT IN COLLEGES AND UNIVERSITIES
1,134.0
1,140.0
FACILITIES AND EQUIPMENT
996.7
1,195.0
INSTITUTIONAL GRANTS
97.0
220.4
FELLOWSHIPS AND TRAINEESHIPS
182.2
233.0
FEDERAL SCHOOLS AND TRAINING OF PERSONNEL
427.4
463.6
OTHER STUDENT SUPPORT
255.6
444.3
TRAINING GRANTS
299.7
328.6
1965 1966 1965 1966 1965 1966 1965 1966 1965 1966 1965 1966 1965 1966
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education


FEDERAL FUNDS FOR VOCATIONAL-TECHNICAL AND ADULT EDUCATION
(ESTIMATED OBLIGATIONS)
IN MILLIONS
$2,500
2,000
1,500
1,000
500
0
VOCATIONAL-TECHNICAL
1,949.6
2,404.6
BASIC ADULT EDUCATION
19.0
33.0
GENERAL ADULT EDUCATION
89.5
115.7
1965 1966 1965 1966 1965 1966
U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education



Mr. VIVIAN. I would like to know the amount of total support for graduate education, which comes from all the Federal agencies. I mean to include Commerce——

Mr. KEPPEL. And Agriculture?

Mr. VIVIAN. Yes, all the agencies. There is also a State contribution, which is quite large in the United States as you go farther west. I would like this identified separately. Although it is a governmental support, it is not Federal.

Mr. KEPPEL. I have more confidence in the Federal data that we have rather than the State matching or the State contribution.

Mr. VIVIAN. I presume that is readily available?

Mr. KEPPEL. We certainly could get it.

(The information requested is as follows:)

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, OFFICE OF EDUCATION

I. Education expenditures, fiscal year 1965

[In millions of dollars]

	Total	Public	Private
Elementary-secondary education [1]	26,900	23,500	3,400
Higher education [2]	12,100	6,900	5,200

[1] Includes adult education and community colleges financed through public elementary and secondary school systems. Federal funds include subsistence payments to individuals in training.

[2] Includes expenditures for subcollegiate departments of institutions of higher education. Federal funds include subsistence and other allowances to individuals in training.

Projected expenditures for education, in current dollars, total $39 billion for 1965. This includes $26.9 billion for elementary-secondary and $12.1 billion for higher education. Data are not available to report higher education expenditures by level (graduate, undergraduate).

II. *Federal funds for education, fiscal year 1965*[1]

[In millions of dollars]

Elementary-secondary education[2]	1,304
Higher education[3]	3,050
Research and development	1,134
Facilities and equipment	997
Graduate training	615
Undergraduate training	219
Agricultural extension	85

[1] Estimated obligations.
[2] Includes adult education and community colleges financed through public elementary and secondary school systems. Federal funds include subsistence payments to individuals in training.
[3] Includes expenditures for subcollegiate departments of institutions of higher education. Federal funds include subsistence and other allowances to individuals in training.

NOTE.—Federal funds for education total $6,329 million for fiscal year 1965. Amounts above exclude programs, such as Federal military training, which are not included with education expenditure data.

Mr. VIVIAN. I don't know how well you can do at the undergraduate level. I would presume the Federal participation in that level is much less than the graduate level.

Mr. KEPPEL. That is right. That is clearly the case.

Mr. VIVIAN. Then as you move to the elementary and secondary levels, I presume the percentage drops down again markedly, and I would appreciate some estimates of the expenditures at these various levels.

Mr. KEPPEL. The overall annual expenditures for elementary and secondary schools is of the order of $27 billion. When you add together the major Federal programs—and may I be an optimist and assume that the Congress will fund the new elementary and secondary act—we have $1.3 billion, to which one would add about three-quarters of a billion dollars more for national defense education, rehabilitation, and technical education. I think one would come out to a figure of roughly 2 billion. I am not including the Department of Agriculture free lunch program. We have something like one-tenth, one-twelfth——

Mr. VIVIAN. That is at the elementary school level?

Mr. KEPPEL. That is right.

Mr. VIVIAN. By the time you get to the college pre-graduate level, I suppose you should label it, your figure is 20 or 30 percent?

Mr. KEPPEL. I don't think it is that high.

Mr. VIVIAN. How about at the grade level?

Mr. KEPPEL. There it is much higher, very high in the sciences and medicine, much less in the humanities. On the other hand, the problem in keeping the books is difficult here. Let me give you an example. In the higher education facilities program that I mentioned earlier in my testimony, I think that 40 percent of the building money is going into libraries, which by the way I heartily agree with, and I suspect all of us would agree to. It is obviously a major contribution to the humanities and the social sciences but how you allocate it, I wouldn't know, sir.

Mr. VIVIAN. Relevant to these estimates, I believe it will turn out that the National Science Foundation's program is a relatively small factor to these determinations, as soon as you include the NASA and DOD funds. Do you have any comments as to whether that percentage

should be increased as a relative percentage? I will then ask you if you think the Office of Education percentage ought to be increased?

Mr. KEPPEL. It is a dangerous thing to ask an educator about more money for anything. The Office of Education percentage I am quite clear should be increased in certain areas. For example, we are before the Congress now, and I feel very strongly about it, with regard to the books that ought to go into these libraries. We have simply got to expand that area. I do not think, sir, at the present time, given our capabilities, the infrastructure and the like it would be wise radically to increase the number of Ph. D. fellows in the title IV of NDEA to which I have addressed myself. This may be a matter of administrative judgment not properly cast against the overall need. I think it is about as fast as we ought to go. As to NSF, those programs that I know best, those with curriculum development and the traineeships and the like——

Mr. VIVIAN. You deal most of the time in the House with the Labor and Education Committee, and you have been very ably presented before them. They have been generous in these last few years and I believe will be generous this year in the higher education program. The NSF budget goes through the Appropriations Committee and there is some tie with this committee. The NASA funds go through this committee. The NIH funds go to another committee as does the Department of Defense. In general, there are a number of congressional committees involved. As the head of the Office of Education, do you feel at any time you have a chance to present the total picture on the financing of education?

Mr. KEPPEL. I have felt no hesitation in presenting the overall story to the House Committee on Education and Labor, recognizing that some parts of it are presented to other committees. I have felt it is my point to try to give the needs and the priorities particularly, and it has been my judgment, sir, that the priorities in recent times are to the needs of disadvantaged children who were simply not getting an even break, to the obvious need of expanding the infrastructure for higher education.

Mr. VIVIAN. Right now your office is a part of the Department of Health, Education, and Welfare. There are many suggestions; there should be the Department of Education which would encompass the educational functions now in other groups. There is also a great deal of resistance. I am curious whether you have any comments you would like to make on that subject.

Mr. KEPPEL. May I make two comments? One of them: If a Government witness may say he isn't competent, the general question, I have thought a lot about. I think it is one of the phenomena of the last quarter century that the institution of education—the schools, the colleges, the universities—have become so enmeshed in the society, all aspects of the society, if I can do it alphabetically from agriculture through science, that in order to accomplish the goals of the society it is necessary to use these institutions. For example, the space program has obviously brilliantly used the resources of the universities as well as the great research enterprise in the private sector, the same in agriculture, the same in other fields. The point I am trying to make, sir, is my own view would be that it would not be wise to attempt, in the

40 Government agencies I believe that use the schools or the colleges to accomplish their particular purpose in one way or another, to get all of those programs under one tent. These schools and colleges, as I say, over the past century, have been paid the greatest of all compliments. They are so useful everyone wants to use them. I am not sure that it is necessarily wise to run everything through one central place like my office. It will probably slow up the paperwork. I don't mean that reorganization is necessarily undesirable, it is probably desirable sometimes, and I would like to disqualify myself for obvious reasons as the witness on this. I don't think we should ever get to the point where the agencies, such as NASA, NSF, and the Agriculture Department, cannot have direct relations with these institutions in our society that are so necessary to carry out their purpose. If there is a little confusion in this, I enjoy it, Mr. Vivian.

Mr. VIVIAN. I anticipated you would say something against such an operation like that, but I wanted to see what it would be. I think I would rather defer from any further questions at this time.

Mr. DADDARIO. Thank you, Mr. Vivian.

Mr. Keppel, we will have a series of questions which I hope we might send to you.[1]

Mr. KEPPEL. Of course, sir.

Mr. DADDARIO. I want to thank both you and the gentlemen with you for a very informative morning. Before these hearings are over, we would like to sit down and talk with you some more about this.

Mr. KEPPEL. I would love to, sir.

Thank you, Mr. Chairman.

Mr. DADDARIO. Our next witness is Dr. Isador Rabi of Columbia University, who has had wide experience in relation to the international aspects of science support. We are pleased to have you here, Dr. Rabi. We understand you had some difficulty in flying down this morning.

STATEMENT OF DR. I. I. RABI, COLUMBIA UNIVERSITY

Dr. RABI. There were a lot of Shriners and so many private planes that we were about an hour late coming down.

Mr. DADDARIO. Would you proceed, please?

Dr. RABI. Sir, I haven't testified before a committee for a long, long time, so I am not quite sure of the procedure you wish. I have a very brief biographical sketch with me and a brief statement perhaps bearing on only one part of the subject. Do you want me to read the biography and statement?

Mr. DADDARIO. The biography need not be read. It will be entered into the record as a matter of course, Dr. Rabi. You may handle your statement either by reading it or by paraphrasing it in any way you like.

Dr. RABI. I will read it, sir, because it is just as good an introduction as any. It is a warming-up period for the questions which you may have.

Gentlemen, I thank you for giving me the opportunity to appear before you to express some views on the applications of science that would make stronger the bonds between our country and nations which are or have been allies and those which have been enemies as

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

well as those who may be considered by some to be our potential enemies.

Since science is universal in nature, it has an appeal to every community on the globe and is, therefore, the commonly accepted intellectual currency of our time. The diffusion of science and the interactions of scientists provide the means of strengthening already existing bonds between our country and others, as well as opening new avenues of communications with countries where such communication has become very difficult or nonexistent.

As an example, I cite you the important role which science has played in the past in opening lines of communication between the United States and the Soviet bloc. The First Conference on the Peaceful Uses of Atomic Energy which took place in Geneva in 1955 broke through the Iron Curtain. For the first time we were able to meet with a large number of important Soviet scientists and to begin a dialog which has resulted in an important lessening of tension between the United States and the Soviet bloc. The most dramatic and significant evidence of the importance of such connections is in the ratification of the test ban treaty.

Another activity which I would like to cite at this point was the proposal which I had the honor of making on behalf of the U.S. delegation at the General Conference of UNESCO in Florence in 1950, where the United States proposed the formation of the now famous laboratory known as CERN, this is a high-energy physics laboratory situated in Geneva, Switzerland. It is the counterpart to the Brookhaven National Laboratory which also is devoted in large part to high-energy physics. There has been a most fruitful collaboration between these two centers as well as friendly competition. CERN is an entirely European organization comprised of about 14 European countries, each of which contributes a proportionate share to the operating and capital budget. The total sum expended is not small. I believe that it has already grown to over $100 million. One point which gives me great satisfaction is that all of this was done without 1 cent of expense to the American taxpayer. It is my hope that the organization which runs CERN may be the forerunner, prototype, or example for greater European cohesion which has been such an important goal of American foreign policy. In contrast to the Common Market, England and most of the EFTA countries are partners in this enterprise.

One more example of the structuring and strengthening of the bonds between countries lies in the work of the NATO Science Committee of which I have been a U.S. member since its inception in 1958. Under this committee, there is a scholarship program which enables various scholars from NATO countries to study in other NATO countries. A research grant program enables scientists to set up projects in which the cooperation of two or more NATO countries are used, both to advance the subject and to promote better relations. Oceanography, particularly of European waters, is a case in point. This committee also supports a large number, something like 45 of this year, of summer institutes which are really advanced schools in a varied range of scientific and technical fields. The institutes have done a great deal for the diffusion of scientific knowledge in the NATO countries, as well as to bring scientists of these countries into close collaboration. This effort has helped to raise the level of Western science in the last few years

and has, I believe, given a greater sense of basic unity to the Atlantic alliance.

Many instances can be added to those I have cited to show the importance of science to international relations. The importance of science in our present and future relations with the other countries in this hemisphere, in the countries of Africa, and of Asia is clear, because science is central to their hopes and aspirations for the modernization required to raise their standard of living to one appropriate to this century. There are many instrumentalities which have been employed to further American policy in these various areas. The military departments and the National Institutes of Health have, through their contract and grant program, done very effective work both in Europe and elsewhere. The National Institutes of Health has made stable contributions and, of course, our great private foundations have pioneered in these efforts.

The National Academy of Sciences has been very effective in maintaining relations with scientists of other lands. The fact remains that we have no central office or organization which could be the flywheel to maintain an even level of effort in communication without great fluctuations which may be dependent on the nature of the military budgets. The National Science Foundation is doing a great deal for the improvement of scientific education in the United States on the secondary school level. These efforts arouse considerable interest, both at home and abroad. The scholarship and fellowship programs are also well known. It, therefore, seems to me that we should try to give the National Science Foundation more funds and a greater opportunity to expand its program and its influence in the international field, in cooperation with the Division of Science Affairs in the State Department.

Gentlemen, I have had for various reasons very little time to prepare these remarks, so it covers only a very small portion of what I might have to say or whatever experience I have had which might be useful to you. I would prefer, instead of going on ad lib, if it is all right with you, to answer questions.

Mr. DADDARIO. Mr. Chairman.

Mr. MILLER. Doctor, may I add to the list of these groups that have worked so well in this field the U.S. Mission for Peaceful Use of Outer Space that meets in Geneva. I think it has made a great contribution to understanding in the world, bringing about the things that you and I desire.

Dr. RABI. Yes, sir. I think that one can make the opening moves in a new relationship through the scientific community perhaps more readily than in any other way, and it is my hope that perhaps in the not too distant future you may make some moves in that direction with respect to mainland China.

Mr. MILLER. Mr. Chairman, in 1960, I had the privilege of being in Paris, Mr. Yeager was along, and we visited the NATO Scientific Committee and saw Mr. Rabi at his best in that committee, and I long remember this fine experience, Doctor.

Dr. RABI. Thank you very much. I might add recently I have begun to see indications of perhaps a warmer coperation to come through the actions of this committee with the French.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. A series of questions, if anyone would like to begin first.

Mr. DADDARIO. No; you go right ahead.

Mr. VIVIAN. In reference to the overall subject of international participation in science, I am quite interested in your remarks that there is no central office or organization to maintain a consistent or balanced policy and level of effort in communication with the foreign scientific communities. You comment on the Division of Science Affairs in the State Department. Does not this Department have a clearly defined function in this area?

Dr. RABI. I think it has, and it has been consistently disappointing in the sense that it has not worked too well for a number of reasons. It is a new graft onto the State Department, and a great deal depends upon the nature, the kind of man who is selected to head this Division and the Secretary of State. I have always pictured that relationship as one parallel, let's say, to the Special Assistant for Science and Technology to the President because, as President Eisenhower discovered, as soon as he had this special assistant, there were very few problems which came across his desk which didn't have a scientific aspect.

The working of this relationship depends a great deal on the people concerned. It has to be in real symbiosis. We have had excellent men in the State Department occupying the position of science advisory, but it has never clicked quite the same way for reasons which perhaps——

Mr. VIVIAN. Some days ago when Dr. Hornig was here, I inquired into the matter of his relationship into national scientific affairs, and I think he indicated that he had a significant responsibility for scientific affairs overseas as well as here, continentally. Would you construe the situation then as one in which the person in the State Department and Dr. Hornig represent the key personnel guiding the subject?

Dr. RABI. That would be the ideal, but, of course, if we are active in science in foreign affairs we need a much bigger staff, the programs have to be examined and evaluated, and neither the Office of Science Affairs in the State Department nor the Office of Science and Technology and the President's Science Advisory Committee have, and I think they should not have, that sort of staff. I would like to see it operate in conjunction with the National Science Foundation but not excluding other agencies which are active in the field. I would like to see some central agency which gathers the experience and the staff over a period of time and which is central, not exactly in coordinating but in operating through this field.

Mr. VIVIAN. In other words, you feel that the operating functions could be well handled at the NSF level whereas the policy guidance would have to come through the State Department?

Dr. RABI. The policy guidance will have to come from the President in various forms—through the State Department is certainly one. Defense has a strong interest and the Congress has a strong interest and the Atomic Energy Commission has a tremendous interest. They are all in this field. They all have representatives abroad, and they are all doing a very good job.

Mr. MILLER. Doctor, because the Science Advisory Committee and the Science Department in the State Department are comparatively new, some time is needed to get acceptance, and isn't this acceptance coming more and more within the Department? I know last year I was invited to go down and discuss the relation of Congress and science at the State Department Institute where they are teaching their new people. This, I think, was the first time that anyone had been invited down there to do this. I hope it will grow.

Mr. VIVIAN. I hope that it will, too, and when I see the excellent people that have gone overseas—I am certain that you know Dr. Piret, who is in Paris and who is coming back now for a year or two. They want him to go back and I don't mean him exclusively to exclude others.

Dr. RABI. Yes, sir. I think it will come. I think it is beginning to be realized more and more in the State Department that this is a responsibility. There have been serious difficulties because the chief man has been there usually at most 2 years. He is a man who comes in without any background in foreign affairs, and about the time he is beginning to have a feeling for the political side, which he has to have to advise the Secretary of State—he has got to turn this scientific material into something which is digestible to the Secretary, which means into the political aspect—by the time he has begun to learn to do this, his term is up and off he goes and there is a hunt for another man. The attachés to whom you refer, some have been very good in gathering information and so on, but the the actual policy guidance, where they might be effective, still has to be improved. They have two jobs. They have to advise the Ambassador and then they have to advise the people back home, and that has to be turned into the kind of information and advice which could be useful. I think we are learning it is new—it is brand new as far as we are concerned. I think we are learning.

Mr. VIVIAN. You indicated a desire for NSF to have a larger international role, which I certainly don't disagree with. That suggests by implication that you might like to see programs similar to those which NSF is now handling on a national scale extended in some way to an international scale, presumably with some U.S. financial participation. Can you outline your thoughts in this area, if you have any you would like to mention?

Dr. RABI. I think in this century, and in the foreseeable future, the prestige of a nation will depend very largely on its scientific strength and the scientific quality. I am talking now on the educational-intellectual scientific side and entirely apart from applications, entirely apart from military strength. These are not unconnected. But if the scientific standing of a country is high, its prestige is high. Its prestige is high, it seems to me, in a way which doesn't frighten people. It shows the beneficent, cultural side of science. I think this is a central and important aspect. The United States in the last 30 years has begun to reach a position of leadership, as the No. 1 scientific country, and I think it is very important to present this to the world in an active kind of way. Likewise, this country I think has done more than any other country in studying the problems of scientific education. I think we have the best universities, the best means in the world of educating a large fraction of the population, large

as those things go, in science and in technology. We have something new. This is not understood abroad because among the great qualities we have is this fantastic ability for self-criticism. Abroad they are likely to believe more of the bad things we say about ourselves than the obvious good things. People in France have complained to me:

You criticize your system so much that our people think they are better when actually they don't begin to be as good.

In this field where the National Science Foundation has pioneered and supported I think it can do a great deal abroad not by spending large sums but by making material available, by discrete use of propaganda. It would very greatly improve the image, I hate to use that word, of the United States. It is very important. Countries as people just don't like to follow strength alone. They want to follow a culture that they can really respect, not only because it is strong and rich. I think in our science we are unquestionably ahead of every other country, as we should be for our size and wealth. I think it should be clearly understood by the general public of those countries. It is understood by the scientists, of course. I think in this field the National Science Foundation can do a great deal as an operating agency through possibilities of fellowships, cooperative projects, visits, and things of that sort.

While I am talking about this I might add it came out very strongly in our committee to which Mr. Miller referred that the Air Force and the Navy and the Army have done wonderful work in Europe and are highly respected for their grants program and the way in which they supervise them and the quality of the work which was done under those programs.

Mr. VIVIAN. Do you think that those programs would be as well or better done under NSF sponsorship rather than military sponsorship?

Dr. RABI. One can't predict because so much depends upon the quality of personnel that is chosen, but I think, given the people, the same kind, it would be easier to do a better job.

Mr. VIVIAN. Let me restrict myself solely to their acceptance of the work rather than the administrative work, do you think they would prefer to see it handled by NSF rather than the military agencies?

Dr. RABI. You mean our customers?

Mr. VIVIAN. Yes.

Dr. RABI. I am sure they would. It is always a shock, due to the history of the European countries. In our country because of the war effort the scientific community formed a close relationship with the military, one of respect, whereas in Europe it is quite different. You will find very few European scientists who are not antimilitary. They have the old image of the military, and in some sense it is well founded.

Mr. DADDARIO. Their scientists do not share that feeling in working with some of the American military departments in these programs. They would just as soon work with a military agency provided the military agency allows them the flexibility that they would like to have, isn't that so?

Dr. RABI. I agree with you. The military have done so well that the original curse, so to speak, is altered, and they have done a very beautiful job in handling it, a very sensitive job.

Mr. DADDARIO. Following Mr. Vivian's questioning in this regard, if the programing and the funding could be expanded under an agency like the National Science Foundation, we would be ahead propagandawise as well as scientifically.

Dr. RABI. I agree, but, as I suggested, I also want to see the flywheel effect when you begin to have the fluctuations in military budgets—and I do hope sometime in the future if we get to a better world that the military budgets will go down drastically, but these other needs that we have in international science will not——

Mr. VIVIAN. Dr. Rabi, you mention in here the fact the changes in science over the last 10 years have had a significant effect on the relationship between the United States and Russia, the degree of communications between these two nations. I have seen this in my colleagues. The large number of trips which have been taken and the remarks and conversations which have been made very obviously have transcended the bounds of the Iron Curtain.

On the subject of international cooperation, I picked a very specific subject some months ago to encourage cooperation rather than the general words. I have suggested strongly to NASA and to other persons in the Government that the Voyager project which leads to the landing of a capsule on Mars some years hence might be a place for scientific cooperation. I believe that scientists throughout the globe feel that the exploration of Mars is of major scientific interest because of the possibilities for life on Mars. I have suggested that the landing which would be quite separate from the conveying vehicle, might, if possible, be designed by an international consortium as a means of spreading our interest in space science throughout the world. Do you have any comments on that type of approach?

Dr. RABI. The object of the mission is to get onto Mars and to get scientific results. That is No. 1. Utilizing this as an example of international cooperation would then be subsidiary. I think it is very difficult in a project as complicated as that to bring in many others because it is difficult and you want success and it is very expensive. You want an organization which is tight, perhaps under a single head. And you would like to have as little as possible of a sort of rivalry which may occur. For that reason I would be afraid of it, particularly if it were international enough to involve the Soviet bloc, simply because of differences in industrial systems, in writing blueprints, everything of that sort.

However, to contradict what I have just told you, at CERN they have built this enormous proton cyclotron, just about the size of our Brookhaven machine, and it cost about the equivalent of $30 million, and parts of it were made by almost every country of the 12 countries which I think were the original members, one chunk or another, and they did it very well, they finished it before we did, and in certain respects it is a better engineered machine than our machine, so it can be done. But I think there you had sort of a romance about it in the sense the industries of different countries decided to do their best, it was all European, which, is another matter, and the principal countries were more or less of a similar size, whereas with the United States cooperating with any other country, except the Soviet Union, it is sort of a horse and chicken hash and it has become very difficult.

Mr. VIVIAN. Dr. Rabi, I would like to point out with regard to my earlier comments on Voyager that the major task of lifting, conveying, and communicating is a task which would certainly have to be done by a single coordinated agency, but the capsule is a device in which there could be many separate experiments. You could get many separate packages put aboard a single entity. I agree with you there are some projects which become difficult without a single point of coordination. However, I disagree with you somewhat on your conclusions with regard to the difficulty of this project.

Let me shift to a different matter. The permeation of science into Europe and into Russia was a relatively straightforward matter in some respects because these nations have been scientifically strong over decades. India and China are two different situations. India has developed a moderately capable scientific community, in fact quite capable. China is developing scientifically as evidenced by their explosion of nuclear weapons. I remember reading Russian scientific material at the end of the war, at the time that the Russians were considered incapable of building anything more than a two by four and they then designed a few items such as ballistic missiles and H-bombs. I have a suspicion that India and China, China particularly, are capable of more scientific effort than we are giving them credit for, having taught many Chinese students in science. Do you have any comments to make on the evolution of science in China and India?

Dr. RABI. It is a miracle to me that the Chinese didn't get to be the greatest scientific nation of the earth. They made so many basic discoveries early in their history. There is no question of their enormous ability. As you may know, in my own department at Columbia we have two Chinese professors; one Madam Wu, who is probably the best experimental physicist—I don't know whether I should add female or not—in the world, a remarkable and charming person, and then, of course, there is Prof. T. D. Lee, who has shared a Nobel Prize. They are simply marvelous people, brilliant, hard working, and charming in every way. I had a fellow graduate student when I was a student at Columbia, his name was Wang, who is now working at the Lincoln Laboratory. He is absolutely brilliant. In fact I have hardly ever come across one that wasn't. There are Chinese all over the United States; in universities occupying very important positions, from Caltech to MIT. So there is no question that this is a remarkably gifted nation, and once they get on the road I think they will be tremendous. There is no question in my mind they will be tremendous because they are industrious and they have the cultural background which is so necessary for both an understanding of science and a contribution to science. If they ever take their rightful place, so to speak, they could be the leading nation in the world unless we really put on our roller skates.

Mr. VIVIAN. It is my impression that they have already taken those steps and they are about to surprise us with their accomplishments. Do you feel that my comments are unwarranted or not?

Dr. RABI. I only regret that we have been unable to go there and see for ourselves.

Mr. VIVIAN. Would you consider it desirable to have a top level scientific team from the United States ask for an opportunity to visit China?

Dr. RABI. More than desirable, I think it is vital, because I think our visits to Russia did an enormous amount to help us understand not only what they were doing but the kind of people they were, something about their connections with the Government and the thrust of that developing culture. Now, we have a new China before us, an entirely new China, but we have no direct experience except fragmentary reports by some English or Frenchman and this is no way for a great country like ours in my opinion to try to understand another great country.

Mr. VIVIAN. Dr. Rabi, I have in the past few weeks suggested to a number of my associates that I feel a top scientific group should visit China at such time as our military relationship is clear enough to be not unpleasant. I even have been interested in taking a trip myself, and I gather you feel that such an effort should be conducted as soon as it is satisfactory between the Governments.

Dr. RABI. If I may digress; I was a member of a committee of five in 1948 of the National Academy chaired by Dr. Bronk who were invited by General MacArthur to visit Japan. We went the length and breadth of Japan, visited different unions and scientists. I think the result of our visit was twofold. We had a much better understanding of the Japanese scientists and their mood and position in the year 1948 at the end of the war, but I think we made an impression and relationships which helped a great deal later on to have these rather satisfactory relationships which we have now.

Mr. VIVIAN. Do you have any comment regarding India in this context?

Dr. RABI. Of course, we have no problem in that respect with India. Our scientists are in and out of India all the time.

Mr. VIVIAN. More specifically, do you feel that we should assist the Indian Government and its private institutions in establishing more active participation in science? I noticed that in a recent film, "Population Control," it was pointed out, I believe by the Indian Ambassador, that the language of science had been one of the very few ways of bringing together the diverse cultures of India itself.

Dr. RABI. Of course, it is very difficult for me to answer anything about India; it is so complicated. There is no question there is a core in India of very high scientific level in science and technology; there is a central core; there are some good leaders; there are very good laboratories, and then there is this great mass of India. I think it would be very good if we could try to help the Indian Government organize itself in such a way that we could help meaningfully rather than have haphazard relationships. That would be a very good thing to accomplish.

Mr. VIVIAN. I would like to switch to a totally different subject, although I have held the floor for quite awhile, Mr. Chairman.

Mr. DADDARIO. You may cover one subject and then we will proceed with the other members.

Mr. VIVIAN. With regard to the diversity of Federal support which is now possible with a large number of agencies supporting frequently parallel activities, do you have any comments or views of the extent to

which this should occur? I realize that most members of the scientific community desire some diversity of scientific support. Do you have any ideas or guidelines as to how much should come from NSF versus some other agency?

Dr. RABI. I was hoping that the NSF role would grow in time to be comparable with the DOD. I think we would have a greater stability. On the other hand, I feel it would be a disaster if the DOD stepped out of the field. There is an obligation on the part of the Defense Department to have its people in close contact, in the close relationships with the scientific community. The only way you can really do that well is to actually support research. The same is true for the Atomic Energy Commission, but somehow we ought, 20 years after the war, to begin to make the civilian side comparable in the support of research and in the support of education.

Mr. VIVIAN. The Director of the Oak Ridge Laboratories was here a few days ago, I am fairly sure you know him.

Dr. RABI. Yes, sir.

Mr. VIVIAN. He indicated that the National Science Foundation support should be well over 50 percent, say, 70 percent. Do you have any comments on these estimates?

Dr. RABI. I am much more empirical. I would like to see us move in that direction and then evaluate the job year by year. I would like to see that become our policy, to let this grow as far as it can without withdrawing too much from the other agencies which need their close contact. Whether it would end up to be 50 or 75 percent or only 40 percent I do not know.

Mr. VIVIAN. Do you see any major new scientific areas in which the National Science Foundation should play an important and increasing role? Are there any areas which you think we are really undernourishing?

Dr. RABI. I like to see the Science Foundation play a role in the high energy field.

Mr. VIVIAN. High energy physics?

Dr. RABI. High energy physics, yes. I feel that we have been backward in exploiting the opportunities in high energy physics. When they start asking the relationship of the support to mission and all that sort of thing, you find it difficult sometimes with respect to other agencies to tie the matter down, whereas since this is pure basic research I would like to see the National Science Foundation get into it. I think they have done an excellent job in the support of radio astronomy and visual astronomy in the form of large national laboratories and so on, and I would like to see them enter the field in a very big way, in two ways in fact.

We need a facility which is so big that it will really represent our best foot forward. I would like to see us proceed as rapidly as possible to making the facility of energy higher than 500 billion volts. My own feeling is that the 200 billion we are talking about is far too small. That can be done by France. I think we should put up something which is really visible and commensurate with the power and qualities which we have. High energy is the growing point of physics, it is expensive, but there are tremendous discoveries being made, and present facilities are fantastically overcrowded.

Mr. VIVIAN. In the 20 to 30 area?

Dr. RABI. Yes. There is just a lot of bad blood being created and competition on that machine. It is expensive but not expensive for us. It would be expensive for a smaller country. But we have to realize how big and wealthy we are and what it is up to us to do, to utilize the circumstances which exist and the tremendous breakthroughs which have occurred in these fields and to exploit them in a significant way. Of course, we would become a magnet for the scientists from all over the world who would come and work.

Mr. VIVIAN. In other words, you would suggest several more Brookhavens at the same energy level and——

Dr. RABI. Yes; and——

Mr. VIVIAN. And the 200——

Dr. RABI. That is too small. It is really not a stopping point. We should go for broke there.

Mr. VIVIAN. How close will be the ones in Europe?

Dr. RABI. They were talking of 300 when they talked of that type. They decided at CERN to make another sort of machine, a storage ring.

Mr. VIVIAN. Does the present American proposal include provision for a storage ring?

Dr. RABI. There is some talk about it. It is not precise. I don't think we have really found a way of talking about these things and planning these things that is good enough.

Mr. VIVIAN. Let me switch you to a different scientific subject. Do you feel that the scientific application of the knowledge of our nervous system and the functions of the brain is receiving adequate attention?

Dr. RABI. It is a field that I deeply respect and admire but I know nothing about. I can't comment. I have heard some marvelous talks, but I would not want to judge the experience in a field which I don't know. If you talk to me about high energy, this I feel in my bones.

Mr. VIVIAN. That is all.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Following this question which Mr. Vivian just proposed with regard to other areas of emphasis by the Foundation, would you care to comment at all with regard to the direction of support for the social sciences as compared with the physical sciences; do you have any views on this?

Mr. RABI. I have heard a great deal of talk about a balanced program, and I don't quite know what it means. I remember when my wife was in college one of the teachers said that she would give this girl an A but to balance the curve she would have to flunk somebody, and she didn't want to flunk anybody, and she did not give her this A. I don't see the support in this way. I think your support comes where things are moving, where progress is being shown. Now, any field in the social sciences that has really shown progress and a breakthrough in understanding I think we should support them for all it is worth, because after all this sort of understanding we need very, very badly, but I would make that as a general principle rather than sort of a balance, that if we give a dollar here we have to give a dollar there.

Mr. Brown. The current level of support for the social sciences by the Foundation is somewhere under 10 percent, and the remainder is going to the physical sciences and the health sciences. I would agree with your philosophy that it is desirable to provide support where it is needed, but I think it is obvious in the past even in the physical sciences we have achieved breakthroughs by giving support even though the need was not as obvious as it might have been.

Dr. Rabi. I don't think the need is so much a measure as the opportunity. Now the social sciences, of course, get a great deal of support from the private foundations which the physical sciences no longer do. I don't know how great the physical science support really is in the sense of where you are supporting people. When we build a big machine, it is the machine, it is industry; the number of people concerned may not be very big although the dollar sign is enormous. I don't know just how to weigh this.

I hope I haven't said anything against the support of the social sciences, it was not my intention, but more or less expressing a philosophy of weighing the kind of support in the sense of opportunity.

Mr. Brown. You made some comments with regard to your own deep feelings about the importance of science as a means of creating the bonds between nations and establishing the conditions under which communications and eventual improvement of relations can take place. This has been true in the physical sciences to a very great extent. I think the physicians have taken the lead in encouraging international cooperation not only among the allies but with the Communist bloc. It seems to me an essential element of the Communist philosophy is that they consider science as the explanation of history and economics and anything else. We do not have a comparable attitude toward the philosophy of science in this country. That is my impression. Would you concur in that? I am not discussing the accuracy of their own self-image with regard to their role but merely posing a general question.

Dr. Rabi. Well, there were various reasons why people did science. If you go back in history, one made these discoveries for the greater glory of God. Another way of looking at it is an example of the spirit of man. Still another way of looking at it is that here we are in this universe, this is our home: we have to find out as much as possible in order to live, to understand how to live right and to protect ourselves against the elements, against nature. Furthermore, it is a very high intellectual expression. And looking further into the future, perhaps not so far, when our technology has advanced so that the working day is shorter and shorter, and you want to hold up something for the youth of this country which will be a real challenge for them, not just to run faster or have a lower golf score, a faster car or whatever, eat seven meals a day, there is only one field, there is only one field which has an endless frontier, an inexhaustible challenge, and that is science, nature in its profundity, in its infinity, in its tremendous variety: that is the challenge. That is the ultimate challenge for a civilized country. I hope we will get to the point where we solve many of our housing problems, clothing, food, whatnot, and have a population that is excellent in physical well-being, but unless they are given some challenge of this sort, they will revolt out of boredom. I

regard science as the thing for us to do and to press on, and at some time or other I expect that we will be expending a very considerable portion of our product, our total effort in the scientific field. It may sound far out.

Mr. BROWN. I am not sure that answers the question that I asked, but I will raise another question. I feel a great deal of sympathy with what you have just said, but you are touching on a matter of the relative importance which a society gives to various elements in that society. This becomes then a matter of culture. What in that culture is valuable? We give value to science over here not for the cultural reasons that you have expressed, but because it enables us to produce more Cadillacs and more air-conditioning units and various things of that sort. I am not sure that emphasis upon the physical science is going to change that aspect of our culture.

Dr. RABI. That aspect of our culture goes way back to the origins of the country. Benjamin Franklin, who I still think was the greatest scientist ever produced in America, spoke that way. He made tremendous advances in theoretical science in the understanding of electricity. However, we are changing and developing. In a country which had to conquer a continent we, of course, had to have that. We are changing very rapidly. The American mathematicians are among the most abstract mathematicians. I can tell you, sir, that within my own period, in my own lifetime, the country is almost unrecognizable when you come to the field of science and education. So I think we are bound to go that way. But fortunately also we are not alone in this world, and the competition with Russia and the Communist countries is going to be very good for us and has been. Look what sputnik did for us. The greatest thing that happened to the United States in recent years was sputnik in the sense of spurring us to a better effort, to a greater effort, reforming our education, making us more aware of these very questions, I don't think that the other countries will let us rest on our laurels, and I am quite sure that given enough time for reflection we are going to support science even more fully in the future than we did in the past, both for our own interest and because of the competition of other countries.

Mr. BROWN. The point you raise is exactly what I am afraid of. I think you describe science as the physical science in the area of competition in the spectacular between ourselves and Russia; the sputniks, high-energy physics, and that sort of thing, when the basic problem that confronts the world today, and I am talking about the Communist and the free world, is the problem in competition involving the underdeveloped world. The underdeveloped nations are not interested in how many sputniks or how many high-energy accelerators we can produce. They are interested in some very fundamental problems such as how you organize elementary education, better agriculture, a more effective or efficient governmental bureaus, and a whole gamut of very unspectacular things. I am afraid that the emphasis we place on the spectaculars in the physical sciences in response to the competitive effect from Russia may be detracting from our ability to compete for the two-thirds of the world that don't care about these things. I am interested in determining if there might be some reason for changing this.

Dr. RABI. I just can't agree with you because as a result of those advances we are just beginning to have the tools to understand our economy, with these computers and these devices, which will enable us to understand the workings of social systems with a large number of ingredients, and the Russians are just beginning to copy us in this respect. I think some of the developments of economic theory in this country and its application and use with modern machines is going to have a tremendous effect on the Russians in this way, not only in economics but in the general theory of the operation of social systems. I think it will also enable us to understand better how we could help the underdeveloped areas. These are just tremendously difficult problems because the whole cultural side has to be involved and the resources and a vast number of factors have to be understood and weighed. I do not believe that social theory, as such, abstract theory, will develop very rapidly. It hasn't. But on the other hand, by studies of the sort, particularly through the use of computers, where you can handle a vast amount of data and try out various ideas, we may have a much more profound understanding of these very questions. We may even be able to understand how our own systems work, which is a miracle and has always been a miracle to us. To me one of the great spectaculars, and will continue to be in the future, is the development of these devices which will enable us to understand what is going on.

Mr. BROWN. Your point is that if we put more money into research in accelerators, computers, sputniks, and Martian probes, there will be a trickle down into the social sciences.

Dr. RABI. You may have to make these devices accessible. That is the important thing. There has to be enough of them, to have enough money in it, enough schools to give instructions on how to use them. You can see how these computers have been lapped up by business. This is how they find out what to do, how to make their policies which they never did before. It is not just a trickle down. So, very often you have devices which have been invented for scientific purposes, very often the physical sciences, which then find this tremendous application in other fields. That has been true all along, and I think it will be true in the future.

Mr. BROWN. Mr. Chairman, I won't pursue this further, but in connection with another point, may I ask if the committee would be able to get information from the DOD with regard to the DOD funding of foreign science education and research?

Mr. DADDARIO. We can get that information.

Mr. BROWN. I want to know, in line with the comments that were made here, the amount of funding for foreign science, basic research, and education, and correspondingly the figures for the military funding of their own military education and management practices with foreign nationals. In other words, how much money is being spent to train foreign nationals in military science and related problems.

Mr. DADDARIO. We can get those questions answered for you, Mr. Brown.

Mr. BROWN. I want to compare the relative impact of DOD in the fields of basic science, research, and military activities.

Mr. VIVIAN. Mr. Chairman, we have a witness coming before us next Tuesday, a Mr. Pollack, Acting Director of International Scien-

tific Affairs for the State Department, and I would be interested in these comments by the time he arrives. I think it is along the same lines.

Mr. DADDARIO. We will see if we can get them. I should think they would be readily available. Some years back we made a study in this field. I am sure we can build upon those.

(The following information has been submitted by the Department of Defense:)

DOD does not sponsor any foreign science educational programs with research, development, test, and evaluation funds. In 1964 we did obligate some $401 million with U.S. academic institutions from R.D.T. & E. appropriations. Since foreign graduate students are being educated at many of these institutions, some fraction of them undoubtedly participated in the university research and development programs supported by these defense appropriations. However, we do not maintain records within the Department of Defense from which the fraction of DOD support pertaining to foreign graduates could be obtained.

In fiscal year 1964 our total obligations for foreign research and development amounted to $29,275,000. Of this amount, only $9,441,000 was obligated for research in foreign academic and nonprofit institutions. Two-thirds of this amount ($6,225,000) was obligated for basic research. Certainly some fraction of this amount supported research activities of foreign graduate students; yet, as in the United States, we are buying research results and graduate education is not an objective in our programs. Thus, we have no records indicating either the number of foreign graduate students involved or the fraction of funds utilized for graduate student support. Generally, even the original research proposals do not yield any clear identification of these research assistants who are also graduate students.

Regarding the allocation of funds to the training of foreign military personnel, figures extracted from the military assistance training program for the past 3 fiscal years are as follows:

[In millions of dollars]

Funding categories	Funds programed by fiscal year		
	1964	1965	1966
Student training[1]	46.6	41.0	35.1
Mobile training teams[2]	4.8	4.6	2.6
Contract technical services personnel[3]	7.1	4.9	2.9
MAAG and Command training support[4]	25.3	23.5	22.2
Other training support[5]	8.5	8.1	9.7
Total	92.3	82.1	72.5

[1] Student training encompasses all instruction given in formal training courses and in orientation training, both in Conus and overseas.

[2] Mobile training teams are small groups of U.S. military specialists sent to foreign countries for periods of not to exceed 6 months for the purpose of conducting training with the indigenous forces.

[3] Contract technical services personnel are civilian technicians, under contract to the U.S. Government, who are sent to foreign countries to conduct training in highly specialized skills (such as maintenance of aircraft and electronic equipment) not available from U.S. military resources.

[4] This includes the operating expenses of the military assistance advisory groups which are attributable to the overall training effort.

[5] Includes expenses related to training of military personnel for their MAAG assignments and reimbursement to Department of State for activities associated with the training effort overseas.

From the above it can be seen that costs most directly attributable to the training of foreign nationals are those listed in the first three categories; i.e., student training, mobile training teams, and contract technical services personnel. The funds programed for this purpose in fiscal years 1964, 1965, and 1966 amount to $58.5, $50.5, and $40.6 million, respectively.

Mr. DADDARIO. You have envisioned a greater role for the National Science Foundation. I imagine when you speak of the flywheel maintaining an even level, you are referring to the National Foundation

as playing that part. You suggest that the National Science Foundation become more involved in high-energy physics. How would this work in relation to the present atomic energy program?

Dr. RABI. It is difficult to be entirely responsive to your question. I certainly would not suggest anything drastic to be done immediately because an organization has to be built up so it can handle these matters, and what I am talking about involves a large amount of money. I should hope that by starting in some subject in a cooperative way; let us say, with the Atomic Energy Commission, then there could gradually be the shift over of some projects into the National Science Foundation. For example, we have a cyclotron at Columbia which was built with the cooperation of the—well, I won't go back to the cyclotron. We have a laboratory called the Columbia Radiation Laboratory, which was started with the Office of Naval Research and gradually became a three-service organization. There have been large cyclotrons which were started at one agency and then became a cooperative project and then went on over to another agency in the end. It was a question of funding and which agency would have the most appropriate interest. This I would suggest would be the direction in which the National Science Foundation should get into things to get its feet wet. First, it has to have some money so as to contribute. In this way they will acquire the management skills necessary for that project, the staff, and ultimately they might take over some of them. I wouldn't suggest it is something which should happen overnight or in 1 year.

Mr. DADDARIO. Your suggestion is that the National Science Foundation analyze areas of opportunity and become a greater participant in these. Even though you don't contemplate that the Department of Defense will step out of any of these fields, you indicate that because there are fluctuating budget problems over the course of time, this might find the National Science Foundation in a necessary role of filling in these gaps?

Dr. RABI. Exactly.

Mr. DADDARIO. Dr. Rabi, we have had some correspondence from the American Institute of Physics, in regard to foreign participation. There is one paragraph in a letter we have had from Van Zandt Williams, the director, and I would like to quote it to you and ask for your comment:

> Our correspondence with U.S. physicists on long-term appointments in developing countries shows that they may have seriously endangered their position in the academic ladder at home. We believe both United States and world science would benefit from measures that encourage qualified students to enter foreign service and that help them to retain their professional standing. We endorse programs that link research programs of foreign universities to those in the United States.

Would you comment upon the fact that our physicists are endangered by such participation and what might be done about it. I imagine you agree with the other comments in that paragraph.

Dr. RABI. It is natural, isn't it, that when a man is absent for a period of time life must go on and he is replaced in one way or another, and if he is given leave of absence and he comes back, he must again construct a niche for himself in the operation of any university department or any organization. They have moved on, the things which interested him are no longer the same, and he must find another place.

This has been very difficult, and is one of the great difficulties in having, let us say, a scientist come to work for the Government, this Government or any other government. After a few years he comes back, and as the Bible says, "There arose a generation which knew not Moses." He had to find his place again. He has to get students to do research; graduate students. His courses has been taken up by somebody else. He may have to displace them or make up a new course, and all that sort of thing, so there is an inherent difficulty. I see no way of solving it except to suggest that if the gentleman played a wider role within his institution, then he could take up a new job using his new experience.

Mr. DADDARIO. Could there be a possibility of retraining?

Dr. RABI. I didn't mean so much that he has fallen behind, although that is true, too, only that his work has been taken over by somebody else. If a man is going to be gone for 3 or 4 years, there are certain courses that will be taken over, a whole generation of graduate students will come along that have never heard of him. He returns with a different experience which should be utilized somehow. It is very hard and I have no very good suggestion. I can just give you an example of what happened during the war. We had a laboratory, the radiation laboratory in Cambridge, Mass., where I was associate director of the laboratory. We had a branch in England. We would send a man over there, a group of men, one man to direct it; let us say, he would come from a very high level within the laboratory itself. He would be gone for a year or so and then it was very hard to fit him in again. He may have been the head of a very important division but somebody else was running it. We had to find a new job for him. It became very, very difficult unless you have an expanding organization. In an expanding organization, of course, he can come right in where there is more to do. I believe on the whole it is going to be a very serious organizational administrative problem of how to handle this. I think is is not only true of the scientific field, but I think it will be true in other fields, too.

Mr. DADDARIO. You encourage that activity and yet you recognize that these men might possibly make a greater sacrifice than perhaps they might have intended in the first case?

Dr. RABI. Oh, yes. I knew it happened to me in my own case, when I began to come to Washington a great deal for the Atomic Energy Commission, and I was not seen so much around the halls of Columbia, so students didn't come to me to get their doctor's degrees and pretty soon I was in trouble, although I did a good job for the United States—I hope I did—I wasn't doing a good job for those students at that particular time. It is a very, very serious matter.

Mr. DADDARIO. Professors have fence-mending problems, too, Doctor?

Dr. RABI. Yes, sir.

Mr. DADDARIO. We have many more questions we would like to ask you, but we are summoned by a quorum call.[1]

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

I hope we will be able to send some additional questions to you. We will try to make them reasonably short. I want to thank you for having come. It has been a very helpful contribution you have made, Dr. Rabi.

Dr. RABI. Thank you very much.

I have enjoyed being here.

Mr. DADDARIO. This committee will adjourn until 10 tomorrow morning at the same place.

(Whereupon, at 12:50 p.m., the committee was adjourned to reconvene at 10 a.m., Wednesday, July 14, 1965.)

NATIONAL SCIENCE FOUNDATION

WEDNESDAY, JULY 14, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. This meeting will come to order.

Our first witness this morning is Dr. Harvey Brooks, who is the dean of the Division of Engineering and Applied Physics at Harvard University. Dr. Brooks has been extremely helpful to this committee in the past. We are very happy to welcome you here, Dr. Brooks, and anxious to hear your testimony.

STATEMENT OF DR. HARVEY BROOKS, DEAN, DIVISION OF ENGINEERING AND APPLIED PHYSICS, HARVARD UNIVERSITY

Dr. Brooks. Thank you, Mr. Chairman.

I will try to go through my written testimony, perhaps omitting some things in the interest of time. As far as procedure is concerned, I would be perfectly happy to be interrupted by your committee as I go through, or to go right through, whichever you prefer.

First of all, Mr. Chairman, I should like to express my appreciation for the invitation to appear before your committee and also my admiration for the thoughtful and responsible way in which your subcommittee has succeeded within a short time in penetrating the complex and difficult issues surrounding the involvement of our Government with science.

With your permission, I should like to make it clear that I am appearing before you in my capacity as a private scientist, and not as a member of the National Science Board, a consultant to the Office of Science and Technology, an officer of the National Academy of Sciences, or even as a Harvard dean. These various hats are not without their influence on my views and help to provide a certain amount of perspective, but I want to make it quite clear that my views do not necessarily coincide with those of the officials of any of the institutions, governmental or private, with which I have some connection.

On the other hand, I would not wish this disclaimer to lead you to expect a sweeping attack on the system of science policy in the United States, or a proposal for radical reforms, for in point of fact I find myself very close to Dean Price, who has testified earlier in these

hearings, in my belief that the system is in very good shape indeed and that, in particular, the National Science Foundation has been a far more constructive and creative force in American science than anybody could have anticipated in the light of the bitter debates and questions that preceded its creation.

You have asked me to address myself to three questions, Mr. Chairman, and I should like to begin by taking these up in the order in which you suggested them. The first refers to criteria of support for basic research. Here I would remind you that I have already set down my views at some length in the paper I prepared for the report, "Basic Science and National Goals," which was prepared for your committee, under the auspices of the National Academy. Today I would like only to underline a few salient points.

In talking about criteria, I think we have to distinguish between three rather different types of basic research in accordance with the type of institution in which it is performed. The three classifications I have in mind are establishment basic research, programmatic basic research, and academic basic research.

First, establishment basic research: There are many Government laboratories or Federal contract research centers with applied mission objectives which nevertheless devote a significant proportion of their total budgets to basic research activities, much as is done in some of the larger industries. This type of work probably constitutes more than 30 percent of all the basic research funded by the Federal Government. Examples are laboratories like Los Alamos or Lincoln Laboratory or Federal laboratories like the Naval Research Laboratory or the National Bureau of Standards.

Second, programmatic basic research: This is the kind of basic research which is sometimes referred to as "big science." It may be defined as organized basic research carried out in an institute established for a programmatic purpose which is related primarily to a specific area of science, rather than to an applied or technological objective. Often such institutes, like the Brookhaven National Laboratory or the National Radio Astronomy Observatory, are established to supplement the work of universities and to provide facilities for university scientists.

One may distinguish two types of programmatic research institutions:

(*a*) Those organized around complex and expensive equipment or instrumentation requiring extensive "care and feeding" by a skilled permanent professional staff. Examples are accelerator laboratories, optical or radio astronomy observatories, laboratories of oceanogaphy, etc.

(*b*) Institutions organized primarily to bring together a "critical mass" of scientists usually from different disciplines to carry out a cooperative attack in a defined area of basic science. It is characteristic of such an institution that in some sense it can be said that the whole is greater than the sum of its parts. The National Center for Atmospheric Research is an example of a laboratory primarily of this character.

The line sometimes between what I have termed "establishment research" and "programmatic basic research" is often hard to draw.

For example, several of the AEC national laboratories, such as the Argonne and the Los Alamos Laboratories, have activities which are clearly establishment research, but they also have separate activities in high energy physics, for example, which are sufficiently separate so that one might properly identify them separately as a programmatic basic research activity.

Thirdly, the category of academic research. This category actually comprises both basic and applied research conducted primarily in connection with the training of graduate students or other research personnel, usually within a university science department or professional school. It would include departmental research in engineering, medicine, and agriculture. It is characterized by being primarily individualistic in approach generally related to the research idea of a single individual, working with a small number of students or associated. I might add parenthetically I think one could also distinguish two categories of academic research which might be classified as mission-oriented academic research and discipline-oriented academic research. By mission-oriented academic research I mean academic research supported by agencies with applied missions for the primary purpose of keeping, as it were, a window on the world of science in order to take advantage of it in their technological activities. Discipline-oriented basic research is basic research supported primarily from the standpoint of developing certain scientific disciplines. Of course, the research of the National Science Foundation is the best example of research which is supported from a disciplinary point of view in that sense.

Unfortunately, these three classifications are only approximate, and there actually exist many intermediate cases. For example, an experiment in high energy physics usually begins as an idea in a university, and the initial instrumentation is designed and built by a professor with a few graduate students, and then, after exposure at a big machine, later interpreted and reported in the home laboratory. Similarly many of the most important experiments in space science have been conceived and designed in relatively modest university facilities before being put aboard a satellite. In each of these examples, however, there is an essential interface between the "little science" and "big science" aspect of the experiment. Before the experiment can actually get time at an accelerator or find a place in a satellite, it has to be approved by a committee and then programed, so that it ultimately requires substantial leadtime and cooperative effort as well as large supporting facilities and staff. The preparatory stages might well be classified as academic research in each example, whereas the actual programing of the experiment must be classified as programmatic research. These two aspects can often be kept separate in financing.

Programmatic basic research, whether or not it requires large and complex installations, is usually characterized by a high ratio of supporting semiprofessional staff to independent researchers, typically as high as 5 to 1 or even more, whereas academic research is usually characterized by more like a 1-to-1 ratio of supporting to scientific staff.

All the three types of basic research mentioned above are essential to the health of our national science and technology. Furthermore, they are closely interrelated, and depend upon rather free circulation of people between the various categories, as well as between basic research and technology. On the other hand, I feel their total funding should be determined by somewhat different criteria and by somewhat different mechanisms.

To add programmatic research and academic research and call this total research is in some sense somewhat meaningless. The choices involved in the funding of both establishment research and programmatic basic research should be much more explicitly political than the choices in the funding of academic research, although obviously the total funding of academic research has to be a political choice as well.

With respect to academic research as a whole the National Science Foundation currently funds only about 13 percent of the total of slightly over $1 billion—this is the category that is usually classified in the statistics as research in the universities proper—although in the future I would like to see this grow to something of the order of 25 percent. I believe it would be undersirable for this to grow to much more than 30 percent for academic science as a whole, and not more than 80 percent for any one field of science, for much of the strength of our system of support for academic research depends on its diversity, on the competition among agencies to seek out and support the best science and the best people, and to provide the most favorable conditions for creative work. When it comes to the support of basic science I am very much an antimonopolist. Assigning exclusive responsibility for a given area of science to a single agency may look good for administrative neatness, but it is the surest guarantee I know of for intellectual, and usually consequently also financial stagnation.

Mr. VIVIAN. Mr. Chairman, I would like to ask Dr. Brooks if he could explain the relationship between the 25 to 30 percent on the previous page and the 80-percent figure which is given for the total support in the field of science.

Dr. BROOKS. The 30- to 35-percent figure really referred to the totality of academic research. I believe it would be unwise for the Science Foundation to be responsible for more than 30 to 35 percent of all of academic research.

Mr. VIVIAN. Can you tell me why you picked that particular number?

Dr. BROOKS. It is somewhat of a number pulled out of a hat.

Mr. VIVIAN. Dr. Weinberg, for example, came up with a figure of 70 percent. I thought that was a bit high, but I think 35 percent is a bit low. I am not objecting, but I am curious to know how you established the number.

Dr. BROOKS. I really established it from a number of qualitative considerations. On the one hand, both from the standpoint of the health of science and also from the standpoint of the health of the scientific programs in the mission-oriented agencies, such as Defense, Space, and so on, I think it is important that they support enough of academic research to maintain a close connection with the academic institutions and with the academic scientists. That I think is one consideration. The other is that I think as much as 70 percent of

academic research being dependent on a single agency runs much greater risk of that bugaboo—Federal control of academic institutions. The plain fact of it is competition among agencies does induce greater freedom of action, greater autonomy in the institutions which are being supported. It is very hard for me to justify quantitatively the number of 35 percent or 30 percent. This is just a visceral feeling. It is three times as much as the present 13 percent, and it is still under 50 percent, and I think this is the best answer.

Mr. DADDARIO. Mr. Vivian, it is my recollection that Dr. Weinberg was referring to the support of basic research in toto and not just academic.

Mr. VIVIAN. Yes; that is correct.

Mr. DADDARIO. So there may not be a proper relationship between the figures.

Mr. CONABLE. I think he also started out with the statement that he would like to see it more than 50 percent, but he did not say 70 percent exactly.

Mr. DADDARIO. After Mr. Vivian had talked with him he said the figures were sliding, but anything over 50 percent would be all right. When we compare Dr. Brooks' figures with Dr. Weinberg's, we ought to be certain we are talking about the same thing.

Mr. VIVIAN. I had the impression that Dr. Weinberg meant roughly the same category, but I don't think anyone has an exact percentage. I am really trying to find out the thought process that went behind these percentages.

Let me take solid state physics, which you are familiar with and which we all agree is an essential field of science for many, many years to come. What percentage of that, for example, would you like to see supported by NASA, AEC, DOD, NSF, and so on?

Dr. BROOKS. I think in that particular field I would argue for something like 60 or 70 percent supported by mission-oriented agencies primarily because these agencies are each so dependent on solid state physics and materials. In other words, it is partly the degree of dependence of the missions of these other agencies on a particular field which I would use as a basis for argument for the total percentage of support that should come from the mission-oriented agencies. On the other hand, astronomy, for example, might well be largely shared in support between NASA and the Science Foundation, and in that field I wouldn't be unhappy to see the Science Foundation have as large a share as, say, 70 percent. In other words, it depends on the relationship of the particular field of science to the mission.

Mr. VIVIAN. In addition to the difficulties with percentages, there is a difficulty in labeling. For example, I concur that a great deal of the applied research or advanced research could be done in these mission-orientated agencies and the rest could be done in NSF. I realize distinguishing labels is a difficult task. Do you have any comments on these intermediary levels?

Dr. BROOKS. Certainly the things that are close to the applied should be done in the mission-oriented agencies but the difficulty particularly in a field like solid state physics is that the line between basic and applied is extremely dynamic and changing very fast, and, therefore, unless the mission-oriented agencies are reaching very far into

the basic end, they are extremely likely to miss the boat. So I think I would still stick to my general rule of thumb that I think in that particular field something of the order of 60 percent of the field would not be at all unreasonable to be supported by the mission-oriented agencies.

Mr. VIVIAN. Thank you.

Mr. DADDARIO. Would you continue, please, Doctor?

Dr. BROOKS. I know one of the questions your committee is interested in is whether the National Science Foundation ought to be less passive in its approach to the scientific community and exercise more leadership in developing new fields or in transferring funds from one area of science to another on the basis of some preconceived set of national priorities. It may be that the National Science Foundation has been too conservative about exercising initiative in the past, but I would hate to see it err in the other direction. The use of "proposal pressure" as a measure of the needs of a given field of science has, in my opinion, been somewhat maligned, and I should like to say a word in its defense. I admit that it is open to abuse. An unscrupulous program officer could in principle manipulate "proposal pressure" from his scientific constituency in such a way as to build up his field at the expense of others, but I seriously doubt whether this kind of gamemanship could go undetected for very long, if only because of the reaction from other fields. I actually know of no instance in which it has ever been really effective. A capable and sophisticated program officer knows how to temper the index of proposal pressure with his own judgment and knowledge of the field. Supplemented by such considerations as the reports of National Academy committees and other panels, I believe proposal pressure is still the best measure we have of the relative needs—and I emphasize the word "relative"—of different fields of science, and I would hope that it would continue to be the primary though not the sole basis of judgment, in the National Science Foundation at least, in the allocation of funds within the category of basic research support grants. Basically it is the system of allocation most likely to lead to the most rapid scientific progress because it is the measure which comes closest to utilizing the day-to-day judgments of the individual working scientist.

On the other hand, I think there are real needs for other mechanisms of support in addition to the project grant system. I believe the science development grant is a step in the right direction. On the other hand, I feel this whole program will lose its point and purpose if the basic research support grants both of the National Science Foundation and of other agencies are not increased to take care of the new capabilities which will hopefully be created by the science development program. Although the institutions which benefit from this program expect to take over support for the new faculty and facilities created, not one of them expects also to take over the financing of the new research capability which is being created. These institutions expect to compete on an equal basis for basic project grants, but it will not serve the purpose of the program if more and more institutions simply compete for a share of a fixed budget. The total financing of all higher education from all sources and at all levels increased at a rate of over 12 percent a year from 1960 to 1963—and I suspect has been increasing even faster since 1963—and only slightly less than 12 per-

cent during the preceding 6 years. With the rapid growth of student population, this growth is likely to accelerate. As a proportion of this total, academic research has increased from about 9 or 10 percent to about 13 percent over a 10-year period. This is a fairly modest increase when one considers the growing importance of graduate work. Actually much of this proportionate increase has been due to the rapid growth of the biomedical sciences, and in terms of the other sciences the proportion of research to total expenditures for higher education has remained probably nearly constant.

Furthermore, contrary to some statements which have been made, non-Federal sources of support have largely kept pace with Federal funding if one confines one's attention to basic research and to "little science." Thus while I look forward to a somewhat more rapid growth of institutional-type grants, the basic research project grant must also grow and grow substantially in the next 10 years if our total system of higher education is to remain healthy and viable.

Mr. VIVIAN. With reference to your statement that non-Federal sources of support have largely kept pace with Federal funding, do you mean non-Federal sources of university research or non-Federal sources of industrial research?

Dr. BROOKS. I am talking about university research. I mean non-Federal sources of university basic research, and I stress the word "basic" because if you look at the total funding of university research, the proportion of Federal funding has increased, but this has been largely due to increases in the applied research area. Apparently the proportion of Federal funding of university basic research has remained about constant during the last 10 years as near at least as I can interpret the statistics.

Mr. VIVIAN. Do you have any information on the Federal support of industrial and allied research outside the universities?

Dr. BROOKS. Yes; I have impressions. I would have to look up the figures. The proportion of Federal funding has certainly increased for industrial research, and just as a very rough recollection in 10 years I think it has increased from about 40 percent of all industrial research to about 60 percent, something of this order of magnitude. I think it has been a switch of 60–40 over a 10-year period of industrial research.

Mr. MOSHER. Do State funds play any important role at all in those non-Federal sources? Is there any tendency among some of the States to increase their direct appropriations for academic research?

Dr. BROOKS. Yes; this is something that I don't have any very clear information on and one of the things I hope to find out more about this summer. It certainly is true that State appropriations for higher education and for research in the universities have been a major factor in the non-Federal sources of support, but just how major a factor is not too clear to me.

Mr. MOSHER. I am sure they are increasing for higher education purposes in general, but I wonder whether States actually earmark funds for research.

Dr. BROOKS. One thing that somewhat confuses the issue in this particular statistic which comes from the NSF so-called intersectorial transfer statistics is that the total includes agricultural research funds, and since these are on a 4-to-1 matching basis for the Federal grants,

this tends to swell the percentage of non-Federal support in the total research picture. One piece of information which we certainly don't have is, for example, how non-Federal sources break down as between private universities and public universities and to what extent non-Federal sources is accounted for by the agricultural matching program and so on. We don't have any real, at least I don't have any real understanding of these relationships as yet.

Mr. DADDARIO. Will you continue, please?

Dr. BROOKS. Coming back, then, to the question of criteria for basic research support let me suggest a list of criteria for each of the three classifications of basic research I have sketched.

(1) ESTABLISHMENT RESEARCH

How much basic research is needed and what basic research is relevant for the achievement of the long range—and I stress the words "long range"—applied mission of the establishment should be primarily a decision of the local management. The departmental administration which supervises the establishment and defends its budget should anticipate that some proportion of the total funding would be spent on free basic research which the establishment director thinks is appropriate. The proportion so spent should be influenced by the following considerations in approximate order of importance:

(*a*) The degree to which the technology used by the establishment in its applied work is dependent on recent advances in basic science.

(*b*) The apparent relevance, as judged after the fact, of the basic research project actually undertaken to the long-range goals of the establishment.

(*c*) The degree to which the basic research program is integrated with and actually stimulates and vitalizes the applied effort. In particular the basic scientists should not be insulated entirely from the applied work and should be available for consultation and should understand and be interested in the applied goals of the establishment.

(*d*) The past performance and achievements of the establishment as related to its applied mission.

(*e*) The competence of the personnel for basic research. However, individual performance in basic research alone should not be as important a factor in the judgment as for programmatic or academic research. Some basic research may be necessary to the total success of the institution, even though it may not be of the very highest quality as judged by usual scientific standards of originality and generality.

(2) PROGRAMMATIC RESEARCH

Here the most important choice is the initial commitment for the creation of a new research institution. Some of the criteria that should be applied to this initial—what I call "strategic"— decision are the following:

(*a*) The availability of able scientists who believe deeply in the program and are willing to stake their personal scientific reputations on its success through actual participation.

(*b*) A convincing argument that the programmatic objectives cannot be achieved as well through existing research institutions or facili-

ties, and that the proposed institution will create a capability which is essentially or nearly unique.

(*c*) The availability of sufficient finance, including a reasonable anticipated rate of growth, and of sufficient competent people, to assure continuing significant contributions to science as judged by a worldwide standard of excellence. Such a project should not be started if its continuing adequate financing implies cutting of support or stagnation of support for other scientific fields or for academic research generally.

(*d*) The novelty and intrinsic intellectual significance of the scientific results it is hoped to achieve.

(*e*) The contribution to and relevance to other important areas of basic science, either current or anticipated.

(*f*) Potential contributions to future technology either directly or indirectly through the qualitative nature of the demands placed on technological capabilities.

(*g*) Contributions to the education and training of future scientists and technologists.

(3) ACADEMIC RESEARCH

The total financing for academic research should be geared to a national policy for the growth of higher education. The research program should be such as to provide significant research experience for all students who are qualified, and in numbers consistent with the national policy. It seems reasonable to expect that Federal expenditures on academic research should expand somewhat faster than total national expenditures on higher education as a whole simply in view of the growing relative importance of advanced research training in higher education and the increasing sophistication of research. In general the fields in which support in provided should be responsive to the interest of scientists rather than explicitly to politically determined national needs, in contrast with establishment of programmatic research where applied needs should be a relevant consideration. Academic research should be biased toward national needs only indirectly through publicizing and explaining such needs and the consequent career opportunities and depending on this information to influence the desires and interests of academic scientists, and hence the demand for research support. The special virtue of academic research from the standpoint of society lies in its individualistic character. Not all academic research need necessarily be of this individualistic character, but it should be predominantly so, and the preponderance of individualistic type research should be carried on in academic institutions. Whether the individual research projects are selected by committees of peers or by the institution itself, the criteria for support should be the same.

Mr. DADDARIO. How do you translate that into action? You establish the criteria. You stress the importance of selection of the individual research project by a committee of peers or by the institutions. Where do you translate this to the point of taking political action? Even though the decision should be within the scientific community, how do you get the funds to do the project, and how do you stir up interest in the program assuming that the scientific community can come to a judgment as to priorities?

Dr. BROOKS. What I am trying to say I think is that within academic research the priorities should be determined primarily in terms of what one might call the market demand modulated, of course, by publicity through such things as national academy reports and so on. I think what I am trying to say is that the virtue of academic research lies really in the fact that the initiative and the ideas and so on come from the individual working scientist, that it is his ideas and his sense of priorities which should primarily govern the allocation of funds within this particular area.

Mr. DADDARIO. How do you reconcile this with the proposal that there should be some basic research which might not necessarily be of the very highest quality in academic research?

Dr. BROOKS. That was referred to under establishment basic research. The criteria that I am talking about here refer to academic research. Perhaps you were asking me about my earlier set of criteria. I was suggesting that somewhat different sets of criteria, particular priorities among criteria, should apply to the three different classifications of basic research. They require somewhat different defenses in relation to the total budget. In other words, with respect to establishment research I made the point that individual excellence of performance might not have as high a priority in connection with establishment basic research as it should have in connection with academic research. It may be necessary to have a certain amount of basic research going on in a mission-oriented establishment even though the quality of that research might not compete effectively, let's say, in the academic marketplace. In other words, different criteria should be applied to establishment basic research than to academic and programmatic research, but the judgment on this of what should be done here I think should be primarily in the hands of the management of the establishment within his total allocation.

Mr. BROWN. We are still talking about Federal support for individual research. I have a feeling that the health of basic research is going to depend upon having a certain number of scientists who are willing to devote themselves to research with no Federal or private funding, but merely research stemming from their connection with the university and its opportunity and their feeling of what is important whether or not they can get funding for it. Am I completely off base as to the desirability of this kind of individual basic research?

Dr. BROOKS. No. Let me—if I could digress on that a moment—I think there is very little basic research today that can be done without some source of funding, whether it be private or institutional or Federal. Perhaps there is some work in pure mathematics which can still be done sitting with a pencil and paper in a dark room provided there is somebody to pay the mathematician's salary, which is presumably the local university, but there are relatively few areas of basic research that don't require some extra source of funding, whether it be institutional or from sources outside the institution. I think the kind of independence that you have in your mind can be achieved to some extent if some of the total funds available for basic research are at the disposal of the institutions or the department, so that an individual, especially the more maverick type of individuals, is not completely dependent on going to some Federal agency in order to get support for a particular project, particularly a project that may not in fact be very well thought out in advance.

Mr. BROWN. What is the role of the basic research which is carried on by members of a university faculty as part of their ongoing professional responsibilities of both teaching and research which is supported because they are on the university faculty. In other words, the researchers don't receive special money from the Federal Government or any other source, they use the time and the resources of the university which are available to them, and they investigate projects or problems which they think are important. Isn't this going on any longer?

Dr. BROOKS. There is a great deal of this going on, much of it with Federal financing.

Mr. BROWN. What do you mean "with Federal financing"?

Dr. BROOKS. Very little of the research that is going on in the university department, even that which is federally financed, is done other than at the instigation and the initiative of the individual faculty member in the university. Usually he gets started on it with university funds and then it grows to a point where university funds are inadequate to carry on the work, and then he seeks other sources of support, depending on what is available. I think the sharp line that you draw between the individualistic research supported entirely within the university and research which is supported by the Federal Government is really not a very realistic line, it isn't that different. One merges over into the other. Even in the federally financed research the salaries of the faculty members and so on are usually financed by the university and the Government contributes technical help, machine shop time, computer time, all the other kinds of things which are now even in the social sciences needed to support a viable research activity. So there is a merging together of these two sources of support, and I don't think you can really draw a sharp line.

Mr. BROWN. What I am looking for is the gate mentioned in your comments that all research has to pass through. This gate seemed to imply that there is no place for research which isn't selected either by a committee of peers or by some other criteria.

Dr. BROOKS. I think in all honesty one has to say that all research that is done in a university is selected in some fashion. Even that which is selected by the individual is selected in a sense. Whether or not the individual received promotion or received an appointment on the faculty in the first place depended on a selection process. So selection is going on at all stages in the system of higher education, whether it is selection of individuals for fellowships or for staff appointments at a university or whether it is selection by a university administrator as to what work or what requests for equipment and so on of a departmental member will be supported and what requests will not be supported. The demands for support, the needs are always much greater than the funds available, whether they be institutional funds or Government funds, or whatever the source of funds, and some selection process has to go on at all levels, whether it be within the university or within Federal agencies. I mean the idea that the university faculty member is completely free to do anything that he wants is inversely proportional to the cheapness of what he wants to do. If it costs money, somebody has to select who gets the money and who doesn't, and it may be within the institution or it may be outside the institution, but there is a selection process going on throughout the system.

Mr. BROWN. I guess I am just old fashioned.

Mr. CONABLE. Wouldn't it be fair to say that a lot of the basic research that he is talking about is involved in simply the preparation of proposals for securing funding of one sort or another?

Dr. BROOKS. Yes; I think this is true. Also, the institutional base grant program of the National Science Foundation has been a tremendously valuable thing in giving the institution funds which can get the younger and lesser known investigators started, give them the few little things they need to get started without having to go back to Washington to ask for funding for a specific project. So this kind of flexibility provided by the institutional base grants is very important in providing just the kind of freewheeling that you are talking about. But still there is a selection process going on within the institution because somebody has to decide who gets supported and who doesn't.

Mr. BROWN. Am I correct in my understanding that a fundamental part of the training of all basic researchers now is how to write proposals so they can get grants?

Dr. BROOKS. Not consciously, at least.

Mr. VIVIAN. Could I make a comment on that? I think one of the problems that the basic researcher finds, in fact, is to know where in the basic university curriculum does he find out how to write proposals for grants. He soon learns.

Dr. BROOKS. Usually within the institution, the graduate students and the postdoctoral fellows and so on essentially receive their support under the umbrella of some more senior faculty member. It is only when they get out with an independent faculty appointment that they are faced with the cold, hard world of reality of seeking support. This support has to be sought whether within the institution or outside the institution.

Mr. VIVIAN. The second part of their experience which they develop within the first 4 or 5 years is to determine which of the Government agencies are located in the Pentagon, which are located on this side of the river, and from which agency they should find support. These things are not taught in the university curriculum, but I am sure they [illegible]

Dr. BROOKS. This is taught by osmosis. I think, Mr. Chairman, I was just in the course of reading the list of criteria for the choice of academic research. [Reading:]

(*a*) The promise of significant scientific results from the project. The evaluation of "promise" implicitly involves the past record of performance of the people who will do the work and their promise of future accomplishment as judged by colleagues or peers. The term "significant" may refer either to intrinsic scientific interest, or to potential applications, or both, but implies some degree of fundamentality and generalizability.

(*b*) The novelty, originality, and uniqueness of the work proposed; the degree to which it breaks new ground, exploits new techniques, or provides a critical test of current theory or understanding.

(*c*) The degree to which the results are likely to influence other work either in the same field or in related or even distant fields.

(*d*) The educational value of the work, based on quality and number of students or other temporary colleagues involved in relation to cost, record of success of past students of the investigator, and the general academic environments in which the work is done.

(*e*) Possible relevance to future applications of interest to responsoring agency. Except in applied-type research this criterion should be given lower priority in academic research, even when supported by mission-oriented agencies than in the case of programmatic or establishment research. I am suggesting that these are the sorts of criteria that ought to be applied either by the committees of peers, the advisory panels and so on that evaluate research proposals, or within the institution by the academic administrators who, in fact, allot funds for research within the institution.

Mr. DADDARIO. How are these criteria being applied by NSF?

Dr. BROOKS. In general I would say these are the criteria that are applied somewhat intuitively, perhaps not explicitly, by NSF panels and, indeed, also by deans and department chairmen in universities. The attempt here really was to try to make explicit for you gentlemen what I think the intuitive or implicit criteria are and that are being applied and I think are properly applied.

The second question you asked, Mr. Chairman, relates to the role of the National Science Foundation as viewed by the individual investigator. To some extent I feel I have already covered this question in the preceding discussion. I would like to stress again the general feeling in the academic community that the National Science Foundation is the agency par excellence which should identify with the interests and the maximum scientific creativity of the individual investigator. Thus, I feel particularly strong that any new ventures on the part of the National Science Foundation should always be carefully evaluated in terms of their effect on the relationship between the National Science Foundation and the individual university scientist. If the National Science Foundation administration becomes too preoccupied with glamorous projects in "big science" or with high prestige applied activities, attention to the needs of the individual investigator may suffer. In general I feel the National Science Foundation should enter programmatic-type research projects only when there is a pretty clear case that they are of such a nature as to extend and support the opportunities available to the university scientific community. Kitt Peak and the National Radio Astronomy Observatory are clearly examples of such activities. I am not saying that university research is the only type of basic research the Government should support but only that it is peculiarly the type of research with which the National Science Foundation should be concerned, and particularly that which pertains to the individual investigator.

There is no question in my mind, also, Mr. Chairman, that the individual scientist prefers the project grant system, with project selection by committees of peers, to all other systems of support. If I have myself occasionally argued for other systems of support, such as institutional grants, it may be partly because of my bias as a university administrator, but also it is my feeling that perhaps the balance has gone a little too far in the direction of purely project support. Nevertheless I would like to make it quite clear that I would never argue that the project support system should not, so to speak, be the baseload of the research support system. The project support systems help the administrator to calibrate his faculty against their peers throughout the country and to reinforce his personal judgments about people in fields remote from his own area of specialization. No academic administrator is possibly competent to judge completely the work of the faculty under his jurisdiction, and if he thinks he can he is exhibiting

a degree of intellectual arrogance with which I have little sympathy. The beauty of our present research support system is that it makes possible an optimum blending of institutional, disciplinary, and personal judgments which is far better than any one of these bases of judgment alone.

There are two other beneficial aspects of the project support system, particularly as used by the National Science Foundation and the National Institutes of Health, which in my mind need emphasis at this time. The first has to do with the coordination of basic research. Almost invariably the individual scientists who serve on study sections of the National Institutes of Health or advisory panels of the National Science Foundation speak of the value of this experience for their own intellectual development, especially in attaining a broader perspective on their own field, and being thoroughly aware in their own work of the work underway in other laboratories. The panel method is a strong influence against parochialism and overspecialization in basic research, and probably one of the more effective ways we have of avoiding undesirable duplication or overlap between researchers. It may, of course, have some tendency to reinforce fashions and to undervalue the maverick or the promising but unusually unconventional young investigator. However, a small proportion of institutional grants can be used to offset this disadvantage. The man who is unappreciated by his own colleagues may be recognized by his peers in his discipline, and the man who is unappreciated by his peers may nevertheless be recognized by his close colleagues.

If we have both methods of recognition and support available within the university I think we will have a better blend than would be possible with either one alone.

An even more important point about project grants awarded on the basis of merit is the recognition they give for outstanding performance, especially in smaller or lesser known institutions. They provide the ideal mechanism by which a capable investigator can be recognized wherever he is, and such recognition often provides an excellent guide to the administrator as to where the real points of strength in his institution lie and where he ought to try to build. Conversely, the fact that even a prestigious scientist can be turned down on a mediocre proposal has a tremendously salutory effect on those who have become complacent with past success and recognition.

You have also raised a question about National Science Foundation statistics. This is a subject that I approach with some trepidation. I think we all agree that research statistics leave something to be desired, yet I would also state without hesitation that the National Science Foundation leads the world in the collection of such statistics. In my recent contacts in Europe through the scientific directorate of the Organization for Economic Cooperation and Development I have been tremendously impressed by the respect and admiration in which Dr. Perlman is held by his opposite numbers in other countries. Dr. Perlman has in the past been responsible for the development of the statistical program, the collection of research statistics in NSF. The trouble with statistics is that the appetite of the policymaker always outruns the menu which the statistical expert is willing to put before him. Always conscious of how easy it is to lie with statistics, the statistical section of the National Science Foundation has been very

reluctant to release or publish numbers for use by people with an inadequate understanding of their limitations. This has often resulted in delays in publication which seem incomprehensible to those of us who do not appreciate the checking and cross-checking which must go into the assembly of valid statistics. Let us not forget that it took more than 30 years to produce reasonable economic statistics for the U.S. economy, and that even today a responsible Government committee can question with some merit the statistics on which our supposed adverse balance-of-payments position are based. Is it any wonder that, in the wisdom of hindsight, some of the National Science Foundation statistics fall short of our best expectations? The problem is not really to criticize the past, but rather to try to learn from our present experience how we may do better in the future.

It seems to me there are two areas in which the National Science Foundation might be able to improve their statistical procedures. First they might make more effective use than they have in the past of studies in depth of relatively small but properly selected samples.

Such studies are in fact beginning. For example, making use of the National Register of Scientific Personnel.

Secondly, I think the planning and statistical groups in the National Science Foundation could make more effective use of the knowledge and experience of the program officers, the people concerned with substantive areas of science. Finally, I would remark that National Science Foundation data collection in the past has both benefited and suffered from being decoupled from the policymaking process. It has benefited in the sense that the lack of strong policy pressures have enabled the statistical groups to develop their system in an orderly and coherent fashion with scrupulous attention to sound methology. It has suffered, on the other hand, from a certain lack of the discipline imposed by the need to find answers to specific policy issues.

In this sense I think the growing complementary roles of the Office of Science and Technology and the National Science Foundation in the formulation and implementation of science policy will serve to strengthen the data collection program of the National Science Foundation by giving it a focus and a policy relevance which was lacking when, essentially, the National Science Foundation had nobody in the Executive Office to talk to. There are already signs that this is taking place, not only as a result of the coupling between the National Science Foundation and the Office of Science and Technology but also because of the interest shown by congressional groups such as this committee in finding quantitative answers to specific policy questions such as geographical distribution of research funds. The policymaking and the data collecting groups have much to learn from each other. Policymakers must learn to appreciate the limitations of statistical data and not draw unjustified conclusions; the data collectors must learn how to design their questions to focus on more specific policy issues and alternatives without overtaxing the system from which the data must be obtained with redundant or unnecessarily detailed questions.

It is often still very difficult to find out from the National Science Foundation statistics what the trends in support of, for example, academic research in specific fields really are. We have no good statistical way of separating programmatic research from academic research or big science from little science. We do not know how to

count the contribution of the big science projects like Brookhaven to the totality of academic research support. The reporting of private and other non-Federal resources going into academic research is 2 to 3 years behind the fact. We know too little about the rising costs of research measured in professional man-years, and what the principal components are in this cost increase. Conversely, although many of us suspect that research productivity measured in results per man-year of effort, has increased rapidly, we have no good tools for measuring this. It is difficult to obtain a clear picture of the significance of research in the total educational enterprise, especially as it varies between disciplines and types of institutions.

Finally I would like to add a few remarks concerning the role of the National Science Foundation in applied science. I know this is something in which your committee has an interest. I find it a complex and difficult question. In general I feel that the National Science Foundation should be cautious about entering applied science areas, and I think it should consider doing so mainly in those areas where the support of applied activities would clearly make an important contribution toward a more balanced advanced training of technologists. Let me amplify.

It is, of course, a commonplace that the universities are the appropriate and logical location for much of the Nation's basic research, especially that having individualistic rather than programmatic character. However, the universities also have an important role to play in the training of engineers, doctors, and other applied scientists. Indeed nearly half of the federally supported research in universities proper is classified as applied, and research is playing an increasing role in the training of engineers and doctors, who must increasingly be "research minded" even to be effective practitioners. Now, whereas the support of research in relation to graduate education in the pure sciences offers no particular policy or educational problems, research in connection with engineering and medical education is much more complicated. The complication is increased by the fact that there are certain basic intellectual disciplines which have been traditionally associated with professional engineering or medicine, even though intellectually they are just as basic, in the sense of being not immediately applicable, as many topics in pure physics and mathematics.

Examples in engineering are communications theory, systems theory, or basic fluid dynamics. These are engineering sciences which can be and are supported under the National Science Foundation's authorization to support basic research.

On the whole these fundamental aspects of engineering have been fairly well supported, at least relative to other fields of basic science and support for them should continue to grow. The basic research support grant is an appropriate mechanism for doing this, although I feel that more use should be made of industrial scientists and engineers on the panels which evaluate such grants supported by the engineering division. However, engineering science is not all of engineering, and the question arises as to what balance of research activity makes for the most suitable environment for the training of graduate engineers, and indeed undergraduate engineers as well, since the orientation and interest of the faculty is largely determined by their research and design activities. This problem of balance between basic and applied

research interests seems to have been reasonably well solved in medical education because the practice of medicine actually takes place within the university complex through the mechanism of the teaching hospital, and through clinical research. However, we have nothing to correspond with the teaching hospital or with clinical teaching and research in engineering and applied science. If a university gets into the business of making commercially useful products or even providing consulting services in competition with private enterprise, there immediately arises a cry of unfair; that is, subsidized, competition. Professor Teller has suggested that large Government-financed installations like the Livermore Laboratory could be used in the training of applied scientists through providing a more complete "real life" engineering environment than is possible on a university campus. This has some merit, but in my opinion falls short of being a real solution of the problem.

In fact, part of the "problem" is that 65 percent of all university engineering research is financed by defense and space agencies, and the absence of corporate support from industry and other Federal agencies has tended to orient both students and faculty away from interest in the problems peculiar to the design of products, processes, and systems where economic and political constraints are of primary importance. Using the Government "big science" laboratories for training purposes will tend to reinforce the bias of engineering education toward the "forced development" Government market, in which economic considerations are secondary. I believe we have here a problem which the National Science Foundation, because of its involvement with graduate education, has to do a good deal of thinking about. Furthermore, I do not believe that the project grant mechanism, which is so suitable for basic research, is as effective for the more applied types of research or for projects in design with economic constraints. Yet I think the National Science Foundation should, in general, stay out of the area of applied research except in cases where extension of its authorization to applied research would clearly contribute directly to its responsibility for the advanced education of technologists.

Thank you, Mr. Chairman.

Mr. Daddario. Thank you, Dr. Brooks.

Mr. Yeager, do you have any questions?

Mr. Yeager. Dr. Brooks, I have two questions in regard to the statistical problem. To your knowledge is the National Science Foundation using adequate, up-to-date instrumentation collecting processes to carry out its responsibilities in the area of data collecting, and, secondly, do you believe that the current ratio of funding within the National Science Foundation's budget is sufficient for this purpose?

Dr. Brooks. To answer your first question, that is an area in which I am rather inexpert; that is, the area of methodology of statistics, and all I can report is the general hearsay that I think on the whole the NSF is using good methodology. On the other hand, that is really just hearsay, and I do not have sufficient expertise in this field to really provide a firsthand professional answer to that question. But generally I think the NSF statistical operation is highly respected from a professional point of view.

The second question, as to whether the funding is adequate, I think is also hard to answer in the sense that from the standpoint of one who

is primarily a consumer of statistics, which I am, my appetite is not satisfied by what the NSF produces. Whether it could be satisfied merely by more funding is a question which is harder to answer. But my feeling is that more funding of the statistical operation of NSF is going to be necessary in the next 5 to 10 years, but whether in fact we have yet a clear enough idea of what exactly needs to be done so that we are really in a position to ask for the funds today and say exactly what we would do with them is a question on which I am considerably more uncertain. One of the objectives of our summer study, which was referred to in Dr. Hornig's testimony, is in fact to take a look at NSF's statistics and Government statistics about research generally from the consumer's point of view, that is to say, from the point of view of the policymaker who needs statistics to make policy recommendations and decisions. So possibly by next fall I will be in a position to give you a little bit more definite answer to that question. That is about the best I can do now.

Mr. YEAGER. Mr. Chairman, I would like to be able to submit any additional questions to Dr. Brooks.

Mr. DADDARIO. Dr. Brooks, we will have other questions. We want to thank you for coming here this morning.[1]

Our next witness is Dr. Shannon. Would you come forward, please?

STATEMENT OF DR. JAMES A. SHANNON, DIRECTOR, NATIONAL INSTITUTES OF HEALTH, ACCOMPANIED BY JOSEPH S. MURTAUGH, CHIEF, OFFICE FOR PROGRAM PLANNING

Dr. SHANNON. Mr. Chairman, may I bring——

Mr. DADDARIO. Yes; I was going to suggest that you have the members of your staff come up.

Dr. SHANNON. This is Mr. Joseph Murtaugh, Chief of our Office of Program Planning, and if we get questions on figures or specifics, with his help I can give you more prompt answers than if I try to trust to my own recollection.

Mr. DADDARIO. Our next witness is Dr. James A. Shannon, who is the Director of the National Institutes of Health. We are pleased to have you here this morning, Dr. Shannon.

Dr. SHANNON. Thank you very much, sir.

Before going into the statement, Mr. Daddario, I would like to call attention to the committee that we have furnished them copies of what is called the "Basic Data Relating to the National Institutes of Health." It includes many statistics relating to the operation of the National Institutes of Health.

I would like to say that my comments, here, will depart in minor ways from that which you have before you because in going over it last night I felt it would go smoother with minor editing.

On page 11 there are two numerical errors that I might correct now. I might say these corrections are bringing statistics up to date from a prior year, and they were only completed yesterday afternoon.

In the last paragraph, the 13 billion becomes 15 billion, and 6 percent becomes 7 percent.

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

Otherwise, Mr. Daddario, I am grateful for your invitation to participate in this review of the National Science Foundation. I will be happy to describe for you the relationships between that organization and the National Institutes of Health, and to give you my views on what the further role of the National Science Foundation should or might be. I particularly value this occasion because I recognize that whatever conclusions are reached here about the present and future role of the National Science Foundation will have an impact on all other science programs, including those of the National Institutes of Health.

The fabric of the National Science Foundation programs cannot be reshaped without setting up new lines of force, that—for better or worse—will affect the ability of Federal agencies to accomplish space, health, defense, and other missions requiring a broad scientific base. Nor can one ignore the possible impact upon our national structure for the support and advancement of science, as the concept and functions of the National Science Foundation change. In a very real sense the National Science Foundation occupies a central position in the structure of our Nation's science support and science advancement programs. To the extent that one redefines the characteristics of this central agency, then one must look also to the total Federal science structure to determine what further modifications will have been made necessary.

A second reason for wanting to talk to you is that in my years of administering health-oriented programs that nevertheless touch and interrelate with NSF at innumerable points, I have formulated some personal but quite definite opinions about what the role of the National Science Foundation in science should be. I will confess at once that you will find nothing original or startling in my views. Others have advanced the concepts earlier—and doubtless more eloquently—than I. My recommendations merely reiterate those you will already have heard. But the perspective—or, if you will, the bias—from which I speak will be very clear to you; and the length of that personal perspective (some 10 years during which the National Institutes of Health and the National Science Foundation have both had their maximum growth rate so far) may add at least an element of interest for you.

What I propose to do is as follows: I will first try to capsulize for you the nature of the present NIH activities, how they got that way, and how—through time—they have interrelated with programs and responsibilities of the National Science Foundation. I will also describe several joint National Science Foundation-National Institutes of Health efforts in common problem solving. I will then discuss my view of the present role of National Science Foundation in science and science education, and what I feel are important considerations relating to the future.

The National Institutes of Health has, as its primary mission, the understanding of disease, behavior, and the biological requirements for health. In the furtherance of this mission, NIH has come to play a major role in the support of research in institutions of higher education in our country. Thus it now has an indirect though major role in strengthening graduate education as such and in adding to the vigor of the institutions which largely contain these research programs.

From the beginning it was recognized that effective support for research carries with it the obligation to enlarge the resource base for continued growth in the future. As a consequence, NIH programs have provided fellowships, have strengthened the structure of graduate education in health-related fields, have provided stable support for faculty expansion, and have stimulated the construction of health research facilities through a matching grant program. This basic spectrum of biomedical research and research-related activities has drawn the National Institutes of Health into close and increasingly fruitful relationships with educational institutions. We have become increasingly aware of the capabilities of Federal programs (1) to support research and, at the same time, to strengthen rather than weaken the educational enterprise, and (2) to broaden the Nation's base of biomedical excellence in all regions of the country.

Some comment on the background of this activity may be helpful in understanding the character of present NIH involvement in scientific activities. To shorten this story I will utilize 3 key years: 1945, 1950, and 1965.

In 1945, as World War II ended, the creation of the National Science Foundation was still 5 years away, though Vannevar Bush and others were urging the need for such an agency. In that same year, NIH was in its 59th year as the research arm of the Public Health Service. Essentially, then as now, NIH was a health agency using science as a means to accomplish its objectives.

The basic authority for NIH programs derives from the statutory responsibility of the Surgeon General of the Public Health Service for the conduct and support of research and investigations related to the diseases and impairments of man and other health problems. The general authorization for this purpose appears in section 301 of the Public Health Service Act. In 1945, however, the tangible attributes of NIH were those of a small in-house Federal laboratory. Less than 6 percent of its funds went to support university scientists, and its total budget was less than $3 million.

But in the circumstances of that year—and especially what had grown out of the war years immediately preceding—were all of the essentials for a vast buildup in Federal science support programs. At least in tentative form, the pattern for future NIH expansion was also present:

There was both the identification of major medical problems and an appreciation that the then current state of the art required a broad expansion of basic science for their solution.

There was also clear evidence of a successful wartime partnership between Government and university science in concentrating scientific effort in needed areas.

There was the effective policy and administrative framework for implementing this partnership that the Office of Scientific Research and Development had worked out.

The National Cancer Institute, added to NIH in 1937, set the pattern of later expansion through creation of separate disease-oriented Institutes.

The Public Health Service Act of 1944 gave broad authority for grant support of extramural research projects.

Finally, the 1946 transfer to NIH of the residual OSRD university contracts in the medical sciences constituted the effective beginning of NIH's present-day broadly based extramural research support program.

By 1950, however, a considerable shift had taken place on the national science scene. In that year, in which creation of the National Science Foundation was authorized by Congress, major research support programs of the AEC and Office of Naval Research were well underway. Seven of the nine research Institutes which comprise the present-day National Institutes of Health had been authorized and their programs launched. In 1950, NIH spent $28 million for research—roughly half going for support of research through grants to academic and research institutions throughout the country. NIH training grants programs were then in their third year; and NIH appropriations for 1950 included $6.4 million for these grants, plus $1.4 million for fellowships.

Thus, by the time the legislative authorization for the National Science Foundation had been completed by Congress, the Federal Government was already heavily involved in the support of academic sciences through the postwar development of the mission-oriented Federal agencies. By reason of this somewhat accidental set of circumstances, the basic pattern was forged for the Federal engagement with science in this country.

Since 1950 NIH appropriations have grown steadily until they now (1965) total slightly more than $1 billion. Although the intramural research activities on the Bethesda campus have grown steadily, the extramural programs have expanded at a much more rapid rate, with the increases being particularly striking during the past decade. Expenditures through extramural programs for research, training, and construction grants now account for nine-tenths of the NIH dollar. As a consequence of this progressive and rapid growth, NIH funds now cover 40 percent of total national expenditures for biomedical and health-related research; and also more than one-third of Federal research funds made available to institutions of higher education. Thus at the present time NIH has a substantial investment in university research, and, therefore, a basic concern with their capabilities for productive research as well as for their future growth.

This extensive NIH involvement with academic science and its institutions—though NIH is not primarily a science agency—does not make NIH unique. This, in fact, has become the hallmark of this country's engagement with science at the Federal level. In contrast with the pattern in a number of major countries—where the support of science is approached directly and as a primary consideration—the advancement of basic science in the United States has been in very large part the derivative of national efforts to achieve nonscientific goals: in agriculture, in national defense, in communications, in health, and in other areas. Though there is room to argue the wisdom of this pattern, one cannot say that the results have been bad. For example, one may speculate—with some confidence—that the scope, the magnitude, and the general excellence of academic science is undoubtedly greater today—as a consequence of efforts directed toward national objectives in the areas of health, defense, and space exploration, et

cetera—than could be expected on the basis of seeking support for science primarily for its own sake. There are many strengths in this situation and I believe this will continue to be the pattern for some time to come. However, there are problems of overall balance across fields of science; there is also the need to advance science education generally, and to assure the resources and development of institutions essential to that advancement. These circumstances make critical the need for a total Federal pattern within which academic science as a whole can be dealt with adequately. In this setting the National Science Foundation has a crucial role.

I should like to take a moment at this point to review for the committee the nature and extent of specific NIH–NSF relationships.

In the development of its programs, NIH has worked continuously and closely with NSF. Collaboration has extended to specific scientific studies; to working out generally comparable terms and conditions of support for research, training, fellowship, and facilities programs in similar settings. The two agencies employ basically the same concepts in respect to the peer group review system for academically based research. There is now a growing concern for coordinating activities and programs which focus upon the same institutions.

I would like to cite a few instances of this cooperation: In the field of research and training grants, the executive secretaries of the various NIH study sections and training committee panels maintain close informal contact with program officials of NSF in coordinating action upon proposals from the same investigators and in areas of common interest to avoid inadvertent duplications. Informal discussions of applications received at one or the other of the two agencies which fall outside of the recipient's support area or interest are referred to the other agency for possible funding. As an example of cooperation in more specific programs and program areas, NIH is included in the interagency chemistry representatives, a group that meets twice a year under the auspices of NSF to discuss common problems in the support of chemistry.

In addition, representatives of NSF are invited to attend all NIH National Advisory Council meetings, and indeed, they do attend.

Mr. Daddario. Could you go into that informal contact and informal discussions a little more thoroughly? How do you choose the people; what is the nature of the contact; who controls it, and does it start at the top or does the informal discussion occur between the same levels at each institution?

Dr. Shannon. I would say it occurs really at three levels. My office has quite intimate contact with Dr. Haworth's office, even to the extent that each year we invite their top staff to discuss with our top staff, or make presentations to our top staff of the generalties of their new programs. There is recurring contact which does not need formalization in terms of a committee structure, particularly with Dr. Haworth, Dr. Wilson, and Dr. Perlman. Dr. Perlman is in the statistical area for NSF, as Mr. Murtaugh's group is for our area. I will come to that a little later.

On the intermediate level there are discussions between Institutes staff and comparable divisions within NSF on the development of specific programs. For example, we are both concerned with develop-

ment of programs utilizing computer technology or expanding computer science. On our side, this is handled by the Institute of General Medical Sciences. I can't recall specifically what the NSF group is called.

There is such intimate contact here in terms of individual proposals that we know precisely what NSF is funding, they know precisely what we are funding, and in a variety of instances there is joint funding.

Then, on the working level, we actually have in some of our technical groups, not just liaison representatives of the NSF, but actually some of the NSF staff as members on our technical committees. I have in mind particularly the Advisory Committee of our Office of International Research, where the behavioral sciences are represented by a staff member of NSF. At still a lower level there is such constant interchange between members of our Division of Research Grants and their counterpart in NSF that to try to formalize this with a committee would be to introduce red tape that would impair the effectiveness of the interchange.

On administrative matters there are joint committees on the terms and conditions of grants, on fellowships, on the handling of overhead—things of that sort. In facilities construction, one of the senior NSF staff members actually sits as a nonvoting member of our Research Facilities Construction Advisory Council.

For general research support grants from the beginning, there has been an intimate and continuing interchange that relates NSF and its objectives to us and to our objectives. Indeed, the general research support grant and its possible extension to the universities was the subject of continuing discussions by a Saturday morning group that was started by Dr. Wiesner and operated over a 6 to 8 month period before general decisions were reached. Here again, it was not only NSF and ourselves that were participants but also Space, AEC, DOD, and the Office of Education; in other words, all of the elements that relate one to the other in framing the generalities of the relationships between the Federal establishment and the university. What I can do, Mr. Daddario, if you would like, is to give you a listing of the formal NIH-NSF relationships in terms of committees; but I would feel that the extraordinary degree of contact between our operation and Dr. Haworth's operation is characterized more by this interdigitation by staff members at all levels than by formal committees.

Mr. Daddario. We understand from the testimony here that the informal relationship between the agencies is far better, even though it is necessary to have a certain amount of formal relationship. I would appreciate it if you could supply us for the record with the formal relationships that exist, and a further explanation of the informal relationships, although you have been quite clear as to why you believe they are important.

As you discuss your relationship to the National Science Foundation, is there anything which indicates that there should be an even closer relationship because of the nature of the work done?

Dr. Shannon. I am going to touch on certain aspects of this as we go on with the statement, but we would be very glad to provide an additional statement.

(The information requested is as follows:)

STATEMENT OF FORMAL RELATIONSHIPS BETWEEN NSF AND NIH; FURTHER EXPLANATION OF INFORMAL RELATIONSHIPS AND THEIR IMPORTANCE; OPPORTUNITIES FOR FURTHER CLOSER RELATIONSHIPS.

Formal relationships.—(1) National Science Foundation representatives attending NIH Advisory Council meetings:

Council	Staff member	Representative capacity
National Institute of Allergy and Infectious Diseases	David B. Tyler	Liaison.
National Advisory Arthritis and Metabolic Diseases	do	Do.
National Advisory Cancer	do	Do.
National Advisory Child Health and Human Development.	Philip Grant	Do.
National Advisory Dental	David B. Tyler	Do.
National Advisory Heart	do	Do.
National Advisory Neurological Diseases and Blindness	do	Do.
National Institute of Mental Health	(Mrs.) Bertha Rubenstein	Do.
National Institute of General Medical Sciences	Fred Hansing	Do.

(2) Also, formal relationship between the National Science Foundation and the National Health Research Facilities Council (advisory to the NIH Division of Research Facilities and Resources) is specified by section 703(a) of the Public Health Service Act. This section reads in part: "There is hereby established in the Public Health Service a National Advisory Council on Health Research Facilities, consisting of the Surgeon General of the Public Health Service, who shall be Chairman, and *an official of the National Science Foundation designated by the National Science Board, who shall be ex officio members,* and * * *." [Italic supplied.] The National Science Foundation has designated Dr. Howard E. Page as its current ex officio member, with Dr. Harve Carlson as alternate.

Other formal relationships.—The NIH and NSF on occasion enter into formal arrangements for the joint support of research projects, research facilities and other scientific endeavors of mutual interest. A complete list of joint funding relationships between NSF and the Division of Research Facilities and Resources is presented elsewhere in records of these hearings.

Examples of joint funding between NIH and NSF, fiscal year 1964

NIH Institute or Division	Title and site	NIH grant or contract No.
National Institute of General Medical Sciences	Precision Biophysical Instrumentation, University of California at Los Angeles.	GM 10689.
Do	Research in Molecular Biology, Yale University.	GM 11948.
Division of Research Facilities and Resources	Chemistry Laboratory, Johns Hopkins University.	FR 03015.
Do	Biological Science Research Facility, North Carolina State College.	RC-936.[1]
Division of Research Facilities and Resources/Multiple Agencies including NSF.	Science Information Exchange	PH-00116-10.[1]
Division of Research Grants	A Study Evaluation of Graduate Education in Major Universities, American Council on Education.	PM 43-64-940.[1]

[1] Contracts.

Informal relationships.—(1) National Science Foundation representatives attending NIH Advisory Committee meetings:

Committee	Staff member	Representative capacity
Scientific Review Committee for Health Research Facilities	Dr. Leise	Liaison.
Advisory Committee on Animal Resources and General Research Support Committee of Division of Research Facilities and Resources.	(1)	(1)

[1] Invite NSF program liaison as necessary.

(2) *Interactions between study section officers (NIH) and program directors (NSF).*—The executive secretaries of the various study sections of the Division of Research Grants and of the training committee panels of NIH maintain close contacts informally by telephone and personal meetings with specific program directors of NSF in cross-checking on details of applications received in common by both agencies to insure that duplicate applications are not jointly funded. Informal discussion of applications received in common by both agencies which fall outside of one support area or interest are referred to the other agency for possible funding interest. This is a standing practice of frequent occurrence.

While the Division of Research Grants (NIH) does not have formally appointed observers from NSF attending its 52 separate study section meetings, informal observers are present at meetings of selected study sections when necessary as determined by common interest of NIH and NSF project reviewing officers. For example, NSF liaison observers are routinely invited and attend meetings of the cell biology, genetics, human embryology and development, and biophysics and biophysical chemistry study sections. Arrangements for attendance of NSF observers in other study sections are made when appropriate because of program considerations or matters involving joint interest on particular projects under review. Similarly, executive secretaries of the NIH study sections listed above are notified of NSF panel meetings and have standing invitations to attend as observers. Attendance depends upon time available from office duties and the nature of topics and awards to be discussed. It has been found that the arrangements made informally based upon mutually determined needs of the officials involved are administratively worthwhile. Questions concerning grant policies at each agency are answered. Each officer is kept informed concerning what the other's agency is tending to support, without influencing the review group in the scientific evaluation of either set of applications.

CONCLUSIONS

At present it is considered that the informal arrangements, based upon mutually recognized common interests, are working well and fruitfully. Formalizing the arrangements would not substantially aid the process. Requiring official attendance at times when discussions have little common interest would unnecessarily hamper program officials of both NSF and NIH in carrying out the full schedule of their duties.

It could be recommended that one senior scientist administrator in NIH be given the responsibility for liaison activities between NIH and NSF, to attend meetings (on invitation) of the National Science Board, NSF, and regularly attend meetings of the appropriate NSF advisory group that will be taking the place of the NSF Divisional Committee for Biological and Medical Sciences (recently disestablished). Such a person could serve as a knowledgeable contact source of information within NIH on NSF programs and developments and similarly answer NSF questions on NIH programs. The NIH and NSF should establish mutual agreement on the role and responsibilities of the proposed liaison officer.

Dr. SHANNON. I would say informally, at this point in time, that there is purposeful overlap in these programs in order to avoid inadvertent gaps in some areas. This is not overlap of an inadvertent nature, and certainly not duplication in the sense that carries an unfortunate administrative connotation. We feel that we avoid inadvertent overlap through the process of joint decisionmaking in many cases, common support of programs, and things of that general sort.

Mr. DADDARIO. It may be helpful if you could give us some examples of how you decide that you should have common support for programing. You stress the idea that you each know what the other is doing in the funding of programs, and that you move on some occasions to joint programing. How you move from the one to the other?

Dr. SHANNON. I can give you two examples, now, if you would like. We felt a very great need to stimulate computer science to the point where more suitable computer software was available to the biomedical sciences as increasing use of computers was made for compu-

tational purposes; for the development of model systems and the like; or the simple handling of complicated data. In the Lincoln Laboratory we had supported the development and actual manufacture of about a dozen small computers that are called Linc computers. These are individual laboratory computers. We became sufficiently interested in the possibility of expanding this activity into new areas that we approached MIT to discuss with them whether they would be willing to establish a group for computer sciences for these purposes, making use of the competencies that were available in the Lincoln Laboratory which is run as an independent subsidiary of MIT.

In doing this, we immediately involved NSF, and conversations from the beginning included the two agencies. We had the dominant interest, and we paid the dominant part of the cost; but there was participation with NSF in that total activity.

Again in the area of science information, for which NSF has broad responsibilities, NIH and NSF have collaborated on chemical documentation problems. NIH's interest is this: the biomedical sciences are totally dependent upon the development of a more adequate information system to handle the interrelationships of chemical structure and biological activity. Now the Chemical Abstracts Service is a subsidiary of the American Chemical Society. It runs what is accepted as the best abstracting service in the country today—one on which all chemists and biologists have very broad dependence. In discussions with this organization about 2 years ago, NIH asked them to undertake a feasibility study on the possibility of developing an alerting system for this type of chemical-biological information. The result was a special abstracting publication called CBAC. Meanwhile, NSF's interest in this general area (also that of the National Academy of Sciences) was in the feasibility of coding all chemical compounds based upon present hardware and present chemical knowledge. For this purpose, the Chemical Abstracts Service had developed a workable system: they put out a journal (Chemical Abstracts). But last year, they reached the conclusion that because of the volume of material becoming available, the Chemical Abstracts Journal would not be publishable in 5 to 7 years. They had to move over to a computer-based system. Before doing this, though, they had to develop a universal system for the coding of all chemical compounds (of which there are somewhere between 2 and 3 million), and a series of subject registers which might relate structure to biological activity.

When we learned of this we asked Chemical Abstracts Service to develop an overall proposal of what they would like to do in terms of National Chemical information needs. We took their proposal to the Office of Science and Technology, saying that we felt this was a problem that went far beyond us. We were willing to put up a substantial amount of money, but we felt the other large supporters of chemical information systems (NSF and DOD) should take or share the lead in a program that would satisfy our needs as well as theirs. OST adopted this position and the result is a program now being run by NSF on funds from NSF, NIH and DOD. We did the preliminary work within my office, developed the elements of a program, and turned over our proposals to OST as the logical organization to pull the Federal agencies together and determine how the program

should be handled. It is being handled by NSF in line with NSF's general responsibilities for the handling of scientific information. This is the type of relationship that has developed between our operation and NSF, which depends more upon intimate knowledge of each other's programs and intimate contact with people than on formal committee structure.

The Division of Research Facilities and Resources at NIH has continuing interchange between its facilities program officials and their counterparts at NSF. This interchange is particularly active when there is need to work out details of joint funding for the construction of building and facilities at particular universities.

In line with your questioning, Mr. Daddario, we can give you a list of joint funding arrangements.

(The material referred to is as follows:)

Construction projects with joint funding from National Science Foundation and health research facilities grants

Institution and location	Description	HRF Award	NFS Award
Alaska: University of Alaska, College	Institute of Arctic Biology	$500,000	$665,325
California: University of San Francisco, San Francisco.	Science building	356,398	50,000
Colorado: Colorado State University, Fort Collins.	Physiology research facility	159,000	459,750
Connecticut: Yale University, New Haven.	Chemistry research building	856,580	250,000
Delaware: University of Delaware, Newark.	Additional space for biological science and psychology.	298,155	300,000
Florida:			
Florida State University, Tallahassee.	Research building	327,928	197,100
University of Florida, Gainesville	Medical entomology research facilities.	6,000	5,200
Do	Nuclear science building	168,865	397,100
Florida State University, Tallahassee.	Chemistry research building	538,104	1,046,425
Do	Biological sciences facility	200,000	500,000
Georgia: Georgia Institute of Technology, Atlanta.	Micromeritics facility	46,379	150,000
Illinois:			
University of Illinois, Urbana	Facility for research on arthropod-borne diseases.	693,015	170,000
University of Chicago, Chicago	Animal behavior laboratory	35,000	80,000
Northwestern University, Evanston.	Technological institute	648,161	88,800
University of Illinois, Urbana	Life science research laboratory	675,723	1,600,000
Illinois Institute of Technology, Chicago.	Life science building	250,000	365,025
University of Illinois, Urbana	Chemistry research building	734,987	1,600,000
University of Chicago, Chicago	do	312,000	1,000,000
University of Illinois, Urbana	Sanitary engineering facility	214,777	1,500,000
Indiana:			
Indiana University, Bloomington	Human physiology laboratory	126,626	8,450
Do	Chemistry wing	371,623	250,000
Do	Research facility, division of optometry.	85,500	100,000
Iowa: Iowa State University of Science and Technology, Ames.	Animal science building	162,769	50,000
Kansas:			
University of Kansas, Lawrence	Vertebrate research wing	45,731	317,500
Kansas State University, Manhattan.	Entomology research facility	102,997	29,200
Do	Biochemical research facility	79,025	273,600
University of Kansas, Lawrence	Behavioral sciences building	397,000	39,525
Maryland: Johns Hopkins University, Baltimore.	Chemistry laboratory	296,634	451,000
Massachusetts:			
Marine Biological Laboratory, Woods Hole.	Biology and basic medical sciences building.	369,250	544,250
Boston University, Boston	Biological research facility	70,522	295,260
Harvard University, Cambridge	Behavioral science building	553,110	1,400,000
Tufts University, Medford	Chemistry department	45,681	130,000
Boston College, Chestnut Hill	Biology science wing	100,000	331,650
Harvard University, Cambridge	Research laboratories for graduate school.	94,051	216,200

Construction projects with joint funding from National Science Foundation and health research facilities grants—Continued

Institution and location	Description	HRF Award	NFS Award
Michigan:			
University of Michigan, Ann Arbor	Social research building	$379,124	$200,000
Michigan State University, East Lansing.	Biochemical and biomedical research building.	2,000,000	1,213,000
Missouri:			
St. Louis University, St. Louis	Research laboratory in chemistry building.	41,926	300,000
Washington University, St. Louis	Experimental biology laboratory	320,599	152,500
Montana: Montana State University, Bozeman.	Chemistry building	69,104	25,000
New Jersey:			
Rutgers, the State University, New Brunswick.	Laboratory of psychopharmacology.	19,837	22,000
Princeton University, Princeton	Chemistry research laboratory	274,937	500,000
New York:			
State University of New York at Buffalo, Buffalo.	Nuclear research center	250,000	564,295
Cornell University, Ithaca	Research building	600,000	1,100,000
State University of New York, Department of Agriculture at Cornell, Ithaca.	Biological sciences facilities	325,000	1,200,000
North Carolina:			
North Carolina State University at Raleigh, Raleigh.	Biological research laboratory	443,125	311,825
University of North Carolina, Chapel Hill.	Zoology building	192,377	399,000
North Dakota: North Dakota State University, Fargo.	Chemistry building	168,640	100,000
Ohio: Miami University, Oxford	Additional research wing	215,534	141,000
Oklahoma:			
Oklahoma State University, Stillwater.	Biochemistry building	145,619	100,000
University of Oklahoma, Norman	Botany and microbiology research facility.	326,200	300,000
Oregon:			
University of Oregon, Eugene	Science building	304,941	51,385
Do	Human research laboratory	67,500	140,800
Oregon State University, Corvallis	Addition to research space	190,000	446,000
Pennsylvania:			
University of Pennsylvania, Philadelphia.	Psychological research laboratory	436,000	400,000
University of Pittsburgh, Pittsburgh.	Health research laboratory	67,611	72,000
Moore School of Electrical Engineering (at University of Pennsylvania), Philadelphia.	Graduate research center (biomedical engineering research).	257,000	493,625
Rhode Island: Providence College, Providence.	Medical research laboratory	122,736	32,400
South Dakota: South Dakota State College, Brookings.	Science hall	50,326	50,000
Texas:			
Texas A. & M., College Station	Plant science building	45,000	100,000
University of Texas, Austin	Biological sciences research building.	425,000	1,375,000
Utah:			
University of Utah, Salt Lake City	Chemistry building	200,000	260,000
Utah State University, Logan	Water research laboratory	250,000	200,000
Virginia: University of Virginia, Charlottesville.	Chemistry building	1,048,000	500,000
Washington: Washington State University, Pullman.	Psychological research facility	102,914	183,000
Wisconsin:			
University of Wisconsin, Madison	Chemistry research building	497,500	1,200,000
Do	Genetics research facility	638,225	122,000
Do	Zoology research laboratory	381,501	368,500
Do	Remodel biochemistry building	30,620	143,850
Do	Biotron facility	1,000,000	1,800,000
Do	Biophysics building	500,000	600,000

Dr. SHANNON. A representative of NSF sits as a nonvoting member with the National Advisory Council on Health Research Facilities when construction proposals are reviewed.

In fellowships, semiannual conferences of Federal fellowships program administrators are held under NSF auspices. At these meetings, common policies on stipend and support levels are nego-

tiated; there are also informal discussions and agreements on delineation of respective scientific spheres, on problems of projections, and so forth.

In the development of resources data, NSF surveys have been expanded to provide the level of detail, especially for the biosciences, needed by NIH. In other instances, such as the 1960 Survey of Foundations and this year's Survey of Research Institutes, the Science Foundation has added a separate sheet for medical and health-related activities; this is made available to the National Institutes of Health for analysis and publication.

Also, the National Science Foundation maintains the National Register of Scientists and Engineers through the use of biennial questionnaires. NSF has made available to NIH decks of IBM cards from this roster for more detailed analysis in fields of specific concern. NSF has also provided NIH with a deck of IBM cards covering the responses of institutions to its Survey of Research Facility Requirements, 1962–70.

NSF and NIH have jointly financed studies and surveys relating to scientific manpower, graduate education, and university activities of common concern and interest. These illustrate only a few of the many continuing relationships that exist between NSF and NIH. This interchange and common action have been cordial, productive, and mutually contributory to the advancement of our respective programs.

From the perspective of an agency supporting science to accomplish nonscientific ends—the eradication of disease—one might pose the question: What should the future NSF role be in the support of science?

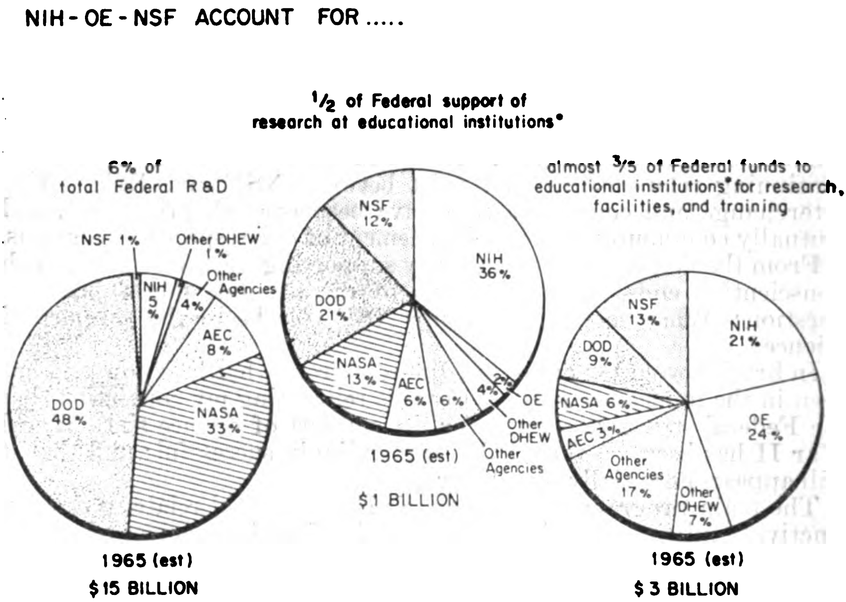
In brief, I would say: not too different from what it is now and has been in the immediate past. I say this reiterating my conviction that the Federal structure erected for the support of science since World War II has been, on the whole, outstandingly successful; and that it still appears essentially sound to me.

The main program strengths of NSF then would relate to the distinctive, explicit, and primary concern for the advancement of science assigned to NSF. These are: the support of basic science research, the enlargement of scientific and technical manpower, advancing the institutional structure and resources for science and science education, and the doing of these things without the restriction of a substantive mission. I believe that NSF should be so funded that it can assure world leadership for the United States in the future course of scientific development. Importantly, this would mean that NSF should be funded generously to fill meaningful gaps and deficiencies in the science structure left by mission-oriented agencies such as AEC, NASA, Defense, NIH, and so forth. It should not, however, be limited to this role. The NSF function in measuring and analyzing the quantitative and economic characteristics of science and its resources is basic to formulation of programs and policy. Its concern with the crucial role of science, as a national resource, as an instrument for strengthening international relations and—in a quite literal sense—as the determinant of the destiny of man, must be reflected in the scope and magnitude of its activities. These views, you will note, are generally in accord with the consensus on the functional concept and "balance wheel" role for

NSF advanced in the recent study by the National Academy of Sciences.

I trust that in what I have said above I will not be understood to be urging adherence to status quo precepts for their own sake, or because they are generally favorable for a particular agency. On the contrary, it is the flexibility and capaciousness of the present science structure that I value and would like to see carried into the future.

As a final consideration I would like to emphasize an important point relating to the present distribution of Federal support for science and related activities which should stand clear to the committee and the Congress in the further pursuit of this inquiry. For this purpose we have prepared a chart. This chart (fig. 1) portrays three aspects of Federal expenditures for research and development:



*Excludes university-managed Federal contract research centers.

SOURCES: Office of Education, National Science Foundation, National Institutes of Health.

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FIGURE 1

The first pie diagram shows the proportionate distribution of total Federal expenditures of $15 billion for research and development amongst the major Federal agencies involved. The inclusion of the large-scale expenditures for hardware development contributes to the dominant positions of the Department of Defense, NASA and AEC in this presentation. NSF, NIH, and other DHEW agencies whose programs are centered in research rather than development account for only 7 percent of the total Federal research and development activity.

In the second pie diagram the focus shifts to that portion of Federal R. & D. expenditure, approximately $1 billion, comprising Federal support of research in educational institutions. This is the area of support for academic science and encompasses the major portion of

the total national support for basic research. In this context the proportionate roles of the several Federal agencies shift markedly: the National Institutes of Health—constituting 36 percent of total—emerges as the Federal agency supporting the largest proportion of academic research.

NIH, together with NSF, the Office of Education, and other HEW agencies accounts for over one-half of all Federal support for research in academic institutions. The critical role of NIH and NSF in sustaining academic science is apparent.

In the third pie diagram, the focus on educational institutions continues. However, the data not only show support for research in such institutions, but Federal expenditures for training and for construction of teaching and research facilities as well. This expenditure is estimated at $3 billion in fiscal year 1965. Here the role of the Office of Education in the support of training and the construction of academic facilities shows its effect. Altogether the activities of NSF, NIH, OE, and other HEW agencies comprise 65 percent of the Federal funds going to educational institutions for training, for research, and for construction. Given the growing dependence of institutions of higher learning upon Federal support, the crucial role played by NIH, NSF, and the OE in the destiny of the national structure for higher education is dramatically emphasized by these data.

The relevance to this committee of the concentration of Federal support for academic sciences in the program of these three agencies is, I think, obvious. There is, moreover, a set of considerations which I should like to depict briefly since they are integral to your concern with the National Science Foundation:

1. Although the Office of Education occupies a dominant position in respect to the support of training and the construction of educational facilities, its role in the support of the substance of science remains minor as shown by the second pie diagram.

2. The NIH and NSF occupy a critical position in respect to the support of university research, particularly in face of declining DOD expenditures in these areas.

3. The further growth of NIH as an agency concerned with the solution of major disease problems will involve positive efforts to provide movement along two fronts:

(*a*) An increased extension of the advances in basic science and technology to the specific problems of the major diseases through applied and developmental activities.

(*b*) Broad efforts to bring the physical, behavioral, and mathematical sciences into more intimate involvement with the biomedical sciences in the provision of stable base for this applied effort. Great care will be required of administrators and legislators in the furtherance of this dual process to avoid distorting an existing balance between that which is fundamental and that which is applied, or bringing one into conflict with the other.

4. Somewhat comparable problems will be presented to NSF. National circumstances will require continuing involvement of NSF in the direction and management of large-scale science projects such as Mohole, radioastronomy, and weather modification. This is sound in terms of the importance of these projects for science and science edu-

cation generally. But it will continue to be sound only if NSF can direct ever-increasing resources to its pivotal role and imperative function of providing for the stability, vigor, and growth of academic science.

Mr. DADDARIO. Do you mean that unless NSF can get the funds to conduct such large projects as Mohole and to do these other things, that it ought not get involved?

Dr. SHANNON. I think that the imperative for the National Science Foundation is to provide a stable base for basic research; if it should turn now to engagement in these large national enterprises, which are essential—but for reasons secondary to NSF's primary mission—I think this would do the country a disservice. If I may be a little critical of the budget action this year——

Mr. DADDARIO. Go right ahead.

Dr. SHANNON. We find support for undifferentiated science is very little different than it was last year, although some of the specialized programs have been expanded. To me this does not make good sense, sir. Quite frankly, this makes our job harder; and one never wants to make his own job any harder than it has to be. I would say the keystone of NSF programs must be support of the undifferentiated, fundamental research which is essential for the health and vigor of our higher educational enterprise.

Mr. DADDARIO. That is the main task for NSF. It ought to be attracted to other tasks only in relation to the funding available to carry out this primary task?

Dr. SHANNON. Yes, sir. I think that there is no doubt that Mohole, radioastronomy, and ground-based optical astronomy are essential projects on the national science scene. They are particularly so for postdoctoral training and the development of scientists that cannot be created at individual universities. But it would be a disservice for the National Science Foundation to accumulate a series of these programs—and more particularly, to go into the applied area, as I know is under consideration, at the cost of limiting its ability to expand in its pivotal role. I think these national resources—and certain concepts in relation to applied work—are important in themselves, but not if they weaken the integrity of our science establishment. This basically depends upon the central role of the university and its ability to provide the opportunity for scientists to conduct research of their own selection, with the concept of excellence determining who shall be supported and to what extent.

Mr. DADDARIO. You have already touched on the critical position of NSF and NIH in regard to the support of university research, particularly as there is a decline in DOD's expenditures in this area. NSF will have an expanding role, perhaps to take up the slack, but if it gets itself involved in other areas at the same time, a declining effect within NSF could be created if it is not careful.

Dr. SHANNON. There are two other things, too, that have a very direct bearing on this. That is, the total cost of these large national efforts is not yet on the books. Once begun, they will of necessity increase.

Mr. DADDARIO. I do not know of any which decrease.

Dr. SHANNON. I haven't seen the budget for Mohole, for example; and I don't know the details of the program. I would guess, though,

that the annual expenditure over the next 5 years will increase fairly dramatically. Certainly this is going to be the case with radio-astronomy. So one looks forward to a mandatory increase in these areas where one has made a national commitment. But the ability to use these resources effectively—and the ability to bring these national programs home with highly productive results—will really depend largely on the extent to which the academic base can be strengthened.

Also in this year's budget, NSF was encouraged to go forward in their science development program, but at the same time, their support for undifferentiated projects was cut back. I think this is an inconsistent action. Unless there is assurance of broader support for this agency, then there is no point in stimulating large efforts just to get more people to compete for less funds. I think these are some of the concepts that one must consider very seriously in viewing the future of agencies such as NSF. Quite frankly, Mr. Daddario, I am concerned that there has not been adequate attention to the long-range consequences of some of the money decisions.

Mr. DADDARIO. Your concern is that the cost of these projects will go up at a greater percentage rate than the support that NSF will get?

Dr. SHANNON. Yes, sir.

Mr. CONABLE. This is one of our difficulties with Government in general. We have had a tendency to consider the resources as unlimited and therefore to accept desirable programs without considering their impact on each other. We have to look at the long-term view or we will be in trouble eventually, and probably in an area of mutual interference.

Dr. SHANNON. I realize your problem, sir, and as I have told our appropriation committee repeatedly, I wouldn't like to be in their position. They have to make some very rough decisions. I would emphasize to you that the agencies that support or relate themselves to academic science spend only 7 percent of the total R. & D. funds. Now I hate to erode other people's budgets for self-seeking purposes, but I would point out that if you take these other agencies and reduce them by 1 percent, I don't think that they would be particularly harmed. But this would result in a 14-percent increase in those agencies that specifically relate to the intellectual base we are trying to build. Indeed, 20 years from now, we will be able to continue to do exciting new work in space, in defense, and in medicine only if during the intervening period we produce the group of highly productive imaginative scientists we will need. The disparity between support for innovation research—whether done in a Federal laboratory or an academic environment—and the tremendous cost for harware development and the like, does give me some pause. I think in the report, Mr. Daddario, that the National Academy of Sciences prepared for this committee, this point was made by a number of people. One concern with our form of government is that within the Congress and the executive branch we tend to fragment science to an inordinate degree, whereas science in the doing is not so fragmented. This is one of the reasons why I was so delighted, Mr. Daddario, to meet with this committee and to express some of these views. Too frequently we at NIH and our science counterparts in other agencies meet year after year with the same congressional groups, who understand our

programs but do not have the opportunity to look at science programs across the board.

I could become very emotional about some of my comments. They stem from my conviction that the last hundred years has brought the United States to the position that it is now in, primarily through the intelligent exploitation of national resources. I think, on the other hand, that where we will be at the end of the next 50 years will depend more on how well we exploit our intellectual resources than on any other single thing.

Because of this conviction, I become troubled when certain things don't happen the way one feels might be optimum. It is this thought that leads me to these expressions of fairly deep concern.

Mr. DADDARIO. We are pleased to have them, Dr. Shannon, and I know they are going to be helpful to us.

Dr. SHANNON. These comments I think have defined the essential areas of relationship between the two agencies—which although quite different in origin, purpose, and role—have been able to accommodate the development of their programs in a mutually reinforcing manner. As I noted at the beginning of these remarks, modification in one agency vitally affects the other.

These are matters which will benefit, I know, from the constructive deliberations of this committee.

I want to thank you for the opportunity which you have provided me to contribute to this important examination of an agency which in 15 short years has become indispensable to the national welfare. I should be pleased to answer any questions, sir.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Doctor, an area of funding which seems to have considerable overlap between the NIH and the NSF, is basic research in the biological sciences. This accounts for roughly a third of the National Science Foundation's activities, and for a much larger proportion of yours. In the area of physical science there is not so much overlap, although there may be. Is this a problem? Have you means or techniques by which, to some extent, you have agreed on a program for mutually supporting funding? Have you tried to establish criteria or standards to determine which will be done by your organization or by the NSF?

Dr. SHANNON. I think there is surprisingly little overlap in the main area of truly mutual funding; that is, the individual research project. There may be a substantial number of individual proposals which could go either place, but the dollar volume of these would be a small portion of the total program. I would say that there is no really large expenditure in terms of a large program that doesn't receive at least the informal joint consideration by both agencies. We would be delighted to submit for the committee an analysis of this area of overlap and try to indicate to you what are the qualitative characteristics generally of those things that we support. We can work with NSF on this and let them indicate for themselves the qualitative character of what they support in this area of potential overlap.

The most obvious interrelation here is the referral from one agency to the other of projects that are considered not suitable for the referring agency but suitable for the other agency. Also, there are quite a few instances of almost identical proposals being sent to both agen-

cies, because the proposer himself doesn't know which program his project will fit into best. These call for central (really joint) decisions on which agency should review the proposal.

Mr. Murtaugh points out a fact that would be of interest to you. In our aggregate funds, 50 percent go into so-called professional schools related to the health professions, and 25 percent to universities, primarily colleges of arts and science and engineering. NSF has its primary "clientele" in universities outside the health professional schools. I can go further and say that apart from these health professional schools, NIH's major preoccupation in universities would be in areas of biophysics, biology, in certain departments of veterinary schools, and so forth. When these specific NIH interests are pulled out, there is quite a different mix supported by NIH within the university group as compared to NSF. We will try to develop——

Mr. Brown. I am satisfied that we are not getting duplication. I was looking for some broad criteria which distinguish that portion of the NSF budget which is concerned with biological science with yours. The remarks you have just made give me some indication of that.

You made some passing reference to the behavioral sciences in connection with NSF. Could you give me a little more indication of what you define to be the behavioral sciences and the nature of NIH's relationship to them?

Dr. Shannon. Yes, sir. We have been intimately involved with the behavioral sciences and indeed, until the development of the National Science Foundation we were the only agency that supported any work in the behavioral sciences. This interest grew of our activities in the field of mental health—the effort to develop an understanding of the behavioral bases for aberrations from the normal. We are concerned with general fields of anthropology and psychology—cultural anthropology in particular; and psychology, from both the standpoint of understanding certain of the mechanics of thought, and of developing suitable testing procedures for change in mental state. But it became obvious more than 20 years ago that the behavioral sciences input into medicine went substantially beyond the problems of mental health. Indeed, most of us at some time in our life have somatic reflections of emotional disturbances of one kind or another, and this becomes the basis of so-called psychosomatic medicine.

The Mental Health Institute, which was created as a research institute in 1946, had a behavioral science program that went beyond its needs for its understanding of specific mental illnesses. For the better part of 10 years it helped to evolve broad competence in our universities in areas tangential to, but nonetheless contributory to, an understanding of mental illness—such as the problems of juvenile delinquency. But even so we felt that our support for the behavioral sciences was developing too limited a pattern. So we asked our Division of General Medical Sciences to engage itself in a broader, noncategorical approach, to the behavioral sciences, with the objective of pointing up the various areas which might have contributions to make to fields of medicine. We were especially interested in aspects of these sciences permitting us to understand better the emotional and intellectual development of the child.

You will appreciate that it becomes quite impossible to discuss mental retardation unless one has a basis for understanding what is nor-

mal. Also, it becomes impossible to study the normal unless one realizes that at one end you have the exceptional child, and at the other end, the retarded child. So, when we were asked by President Kennedy to consider setting up an Institute of Child Health—with mental retardation to be a major concern—we countered by saying that we felt there was not an area of child health, per se, that made sense to us, but rather, we would like to approach the problem in terms of human development. As a counterproposal we said we would like to organize an Institute of Human Development.

Without going further into the why's or wherefore's, we now have an Institute of Child Health and Human Development, and I think this is fine. But when we talk about development, we talk about emotional, intellectual, and biological development of the child. And when we talk about emotional or intellectual development, we are right across the border into the behavioral sciences. This new Institute is now in the third year. It is just beginning to engage itself seriously in such problems as development of intellectual capabilities, the emotional reactions of humans, and so forth. Basically I would say NIH is a health agency rather than a disease agency. Until we know more about the normal—the factors that contribute to normalcy, and the factors that relate to the development of speech and educational ability, also the emotional response of a child during the rapidly changing years from 3 to 5—then I don't think we are in a position to interpret disease manifestations in those systems. In this sense, we now have gone far into the behavioral sciences as compared to the early attempt to find a base for the manic depressive personality or the schizoid and things of that general sort. This involves us and will involve us increasingly with the university.

Mr. Brown. Didn't this lead to a further expansion of what you might call the human environment or environmental science in which you will reach the conclusions that behavioral manifestations may stem from economic circumstances or from cultural situations?

Dr. Shannon. We are already into that, sir, at the present time because mental retardation is known to be due more to social deprivations than any other single cause. I don't think we will have to do anything about solving the underlying social problems, but will have to define the circumstances in which social deprivation contributes to mental retardation, and find the best ways of handling the child who has been retarded.

Mr. Brown. I wish in addition to identifying the problem you could identify the solution, but I recognize this may not be appropriate for the National Institutes of Health. I am concerned with the extent to which your resources are now being devoted to identification of the behavioral sciences and environmental conditions, because I think they are closely related and deeply involved in our health problems today.

Dr. Shannon. I will give you another area where the health problem is equally involved with socioeconomic circumstances; and there are medical, biological and behavioral elements: the area of aging. If we were able to apply all the knowledge we have at the present time to the problem of aging, we could greatly diminish its impact as a national problem. But the relevant solutions are more in the socioeconomic than strictly the medical field.

I think it is NIH's responsibility to attempt to define what are the behavioral and biological characteristics of the aging process and what are the inputs that contribute to this process. But I don't think it is our job to go beyond this in relation to socioeconomic aspects.

On the other hand, other elements of the Public Health Service, particularly the community health part of the Bureau of State Services, have the authority to conduct certain experimental ventures in attempting to modify some of the environmental factors. Essentially, though, the underlying socioeconomic problems relevant to the socially deprived child and the aged are being approached by the welfare agencies rather than the health agencies.

Mr. BROWN. My line of questioning is aimed at trying to identify the importance of social science and the degree of support that is being obtained for it through both NIH and NSF. When we discuss the behavioral sciences, the environmental sciences, we are talking about the social sciences; we are talking about basic economics, sociology, psychology, which are not generally considered to be biological or physical. I would like to have you comment on the amount of support which is going into these areas from the NIH.

Dr. SHANNON. Could I make one statement before commenting on the amount? I will give you a rough figure, and we will correct it in the record.

First, we have no category of support for the social sciences as such. On the other hand, within the social sciences are the elements that I spoke about earlier; that is, psychology, cultural anthropology, and so forth. Our figures would indicate that in the aggregate we are spending about 10 percent of our total resources in the social sciences. But this is spent only in those areas where our program staff see peculiar relevance to problems of health. But if I may, I will insert in the record the dollar value and the institute involved in these expenditures.

(The information requested is as follows:)

NIH funding in the psychological and social sciences, fiscal year 1964

[Thousands of dollars]

1. TOTAL, ALL INSTITUTES

Field	Total	Research [1]			Training			
		Research grants	Collaborative studies	Direct research	Training grants	Fellowships	RCA [2]	Traineeships
Total, all institutes	76,046	40,829	2,979	3,743	21,289	4,670	2,525	11
Psychology, total [3]	47,360	26,627	2,721	2,869	9,395	3,409	2,328	11
Biological psychology	30,823	15,818	2,280	819	7,582	2,564	1,749	11
Social psychology [4]	16,537	10,809	441	2,050	1,813	845	579	-------
Social sciences, total	28,686	14,202	258	874	11,894	1,261	197	-------
Anthropology	3,157	1,424	-------	264	782	620	67	-------
Economics	-------	-------	-------	-------	-------	-------	-------	-------
Sociology	11,655	8,895	258	610	1,309	453	130	-------
Other	13,874	3,883	-------	-------	9,803	188	-------	-------

See footnotes at end of table, p. 394.

NIH funding in the psychological and social sciences, fiscal year 1964—Continued

[Thousands of dollars]

2. NICHD TOTAL

Field	Total	Research [1]			Training		
		Research grants	Collaborative studies	Direct research	Training grants	Fellowships	RCA
NICHD, total	4,894	4,140	84	15	380	58	217
Psychology sciences, total	4,704	3,974	80	14	380	39	217
Biological psychology	3,430	3,062	60	10	140	33	125
Social psychology [4]	1,274	912	20	4	240	6	92
Social sciences, total	190	166	4	1		19	
Anthropology							
Economics							
Sociology	179	166	4	1		8	
Other [5]	11					11	

3. NIDR TOTAL

Field	Total	Research			Training		
		Research grants	Collaborative studies	Direct research	Training grants	Fellowships	RCA
NIDR, total	129				109	20	
Psychology, total	123				109	14	
Biological psychology	83				69	14	
Social psychology [4]	40				40		
Social sciences, total	6					6	
Anthropology							
Economics							
Sociology	6					6	
Other							

4. NIGMS TOTAL

Field	Total	Research [1]			Training		
		Research grants	Collaborative studies	Direct research	Training grants	Fellowships	RCA
NIGMS, total	1,530	419			1,027	53	31
Psychology sciences, total	660	134			471	24	31
Biological psychology	566	134			377	24	31
Social psychology [4]	94				94		
Social sciences, total	870	285			556	29	
Anthropology	286	47			239		
Economics							
Sociology	309	50			259		
Other [6]	275	188			58	29	

See footnotes at end of table, p. 394.

NIH funding in the psychological and social sciences, fiscal year 1964—Continued

[Thousands of dollars]

5. NHI TOTAL

Field	Total	Research			Training		
		Research grants	Collaborative studies	Direct research	Training grants	Fellowships	RCA
NHI, total	90				90		
Psychology sciences, total	52				52		
Biological psychology	52				52		
Social psychology [4]							
Social science, total	38				38		
Anthropology							
Economics							
Sociology							
Other [7]	38				38		

6. NIMH TOTAL

Field	Total	Research [1]			Training		
		Research grants	Collaborative studies	Direct research	Training grants	Fellowships	RCA
NIMH, total	66, 280	34, 031	2, 489	3, 590	19, 484	4, 478	2, 208
Psychology sciences, total	38, 698	20, 280	2, 235	2, 717	8, 184	3, 271	2, 011
Biological psychology	23, 610	10, 383	1, 855	671	6, 745	2, 432	1, 524
Social psychology [4]	15, 088	9, 897	380	2, 046	1, 439	839	487
Social sciences, total	27, 582	13, 751	254	873	11, 300	1, 207	197
Anthropology	2, 871	1, 377		264	543	620	67
Economics							
Sociology	11, 161	8, 679	254	609	1, 050	439	130
Other [7]	13, 550	3, 695			9, 707	148	

7. NINDB TOTAL

Field	Total	Research [1]			Training			
		Research grants	Collaborative studies	Direct research	Training grants	Fellowships	RCA	Traineeships
NINDB, total	2, 836	1, 981	[8] 406	[8] 138	199	32	69	11
Psychology, total	2, 836	1, 981	406	138	199	82	69	11
Biological psychology	2, 795	1, 981	365	138	199	32	69	11
Social psychology [4]	41		41					
Social science, total								
Anthropology								
Economics								
Sociology								
Other								

See footnotes at end of table, p. 394.

NIH funding in the psychological and social sciences, fiscal year 1964—Continued

[Thousands of dollars]

8. DRFR TOTAL

Field	Total	Research			Training		
		Research grants	Collaborative studies	Direct research	Training grants	Fellowships	RCA
DRFR, total	258	258					
Psychology sciences, total	258	258					
Biological psychology	258	258					
Social psychology							
Social science, total							
Anthropology							
Economics							
Sociology							
Other							
OIR, total	29					29	
Psychology, total	29					29	
Biological psychology	29					29	
Social psychology							
Social sciences, total							
Anthropology							
Economics							
Sociology							
Other							

1 Figures exclude operating costs, thus differing from NSF published data on NIH which include amounts for the review, approval, and administration of grants.
2 A list of abbreviations and the related complete terminology for this and subsequent tables is provided below.
3 Psychiatry excluded in this and subsequent tables.
4 Includes educational psychology and personality psychology.
5 Social sciences, "Other" includes social work only under "Fellowships."
6 History only.
7 Includes social work only in "Training."
8 Estimate only.

ABBREVIATIONS

The following abbreviations are to be found on the preceding tables:
RCA—Research Career Awards.
NICHD—National Institute of Child Health and Human Development.
NIDR—National Institute of Dental Research.
NIGMS—National Institute of General Medical Sciences.
NHI—National Heart Institute.
NIMH—National Institute of Mental Health.
NINDB—National Institute of Neurological Diseases and Blindness.
DRFR—Division of Research Facilities and Resources.
OIR—Office of International Research.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. No questions.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. On page 6 of your testimony, you say: "NIH is not primarily a science agency."

On page 2 you indicate that it has as its primary mission "the support of medical research."

Dr. SHANNON. There may appear to be some inconsistencies because I did some editing last night to my remarks as you have them there. In any case, the sharpening up of what our mission is stems really from the Wooldridge Committee, that analyzed our activities from the standpoint of the relative degree of the excellence of the research work that we supported. They looked at the distributed parts, rather than at the whole of NIH, and came to the conclusion that we

were an agency not too different from the National Science Foundation except that we concentrated our activities in the biomedical field while the National Science Foundation concentrated on the physical sciences and mathematics. We take a different view, based on the total thrust of NIH concern; we are a health agency. We exist purely for purposes of finding solutions for disease and an understanding of health. However, these purposes require establishing a very broad base of fundamental research because of our ignorance of certain areas in the biological sciences, and our inability to find answers of an applied nature at this point in time. So our mission is a social mission; namely, the conquest of disease and the provision of buoyant health; but the devices we use to find answers to these problems are highly scientific. The Department of Defense also has a social mission; to conserve the physical and moral integrity of our Nation; but it also uses science in no small measure as a means toward that end. Our end is the conquest of the disease and the maintenance of health, and we use science to achieve that end.

Mr. VIVIAN. I had the impression that NIH's mission was not the conquest of disease, but providing knowledge as to the conquest of disease. You indicated before to Mr. Brown that you were not trying to cure mental disease, but how it could be cured, and what the problem is.

Dr. SHANNON. That is not entirely correct, in the sense that we are a part of a larger agency, the Public Health Service.

Mr. VIVIAN. That I agree with, but NIH is specifically related to determining the cause of disease.

Dr. SHANNON. If you extend that to the means whereby cure can be accomplished.

Mr. VIVIAN. I didn't wish to exclude that.

Dr. SHANNON. We are primarily the research arm of the larger structure called the Public Health Service, and it is from this perspective that we state our mission as I have stated it to you.

Mr. VIVIAN. If the Public Health Service's goal is the improvement of the health of the Nation, then in a sense social sciences would presumably be part of the Public Health Service, whether or not in NIH?

Dr. SHANNON. This is why I mentioned the Bureau of State Services. The segment of that Bureau that deals with community health does have certain experimental procedures that relate to the handling of our elderly citizens and modifying the environments relevant to health problems.

Mr. VIVIAN. I am not sure whether on page 6 your present remarks exclude the phrase, "Though NIH is not a science agency." However, I have difficulty in understanding why it is not primarily a science agency.

Dr. SHANNON. I suppose what we get involved in is how we use words, what they mean to you, sir, and what they mean to me.

Mr. VIVIAN. Let me go to page 9:

> The Science Foundation has added a separate sheet covering medical and health-related activities.

I construe this as meaning that ordinarily they would not have covered medical and health-related activities because they are not pertinent to the Science Foundation's coverage area?

Mr. MURTAUGH. That is not quite correct. In their collection of data they would not have identified as a category those activities of a foundation directed toward the medical and health area which we would be interested in.

Mr. VIVIAN. Why not?

Mr. MURTAUGH. They would be included in the total. For instance, they would identify the research expenditures of a foundation directed toward broad areas of science. We have worked with the Science Foundation in attempting to obtain detailed breakdowns of this reporting to identify specific areas of interest to us; just further detail is all.

Mr. VIVIAN. My impression is that the Wooldridge report has a good deal of validity in reference to the NSF–NIH relationship. I am not at all convinced that the present relationship is a very wise relationship or the best one. I will come back to that one in a moment. Is there any mission in the field of health which is allowed to NSF?

Dr. SHANNON. In health per se I would say, no, sir.

Mr. VIVIAN. There is no mission in defense normally——

Dr. SHANNON. In defense there is, sir. In defense there is a very specific health mission.

Mr. VIVIAN. I am sorry, I am saying I believe there is no mission in the defense area which is allowed to NSF.

Dr. SHANNON. I am sorry. This I don't know.

Mr. VIVIAN. There is presumably no mission in transportation in the sense that NASA covers the upper space transportation and the Commerce Department covers the lower space transportation. I want an answer to the question what mission, if any, does NSF have?

Dr. SHANNON. It depends on how you define mission. I think I view the need for (or, if you will, its mission), in this way: Take a national situation wherein one must create a very broad program of research and development in order to accomplish the essential social missions—defense, health, or what have you. To accomplish these social missions, one requires an extraordinarily sound general purpose scientific establishment within the Nation, both for the education of our people and the training of scientists. I think NSF's mission then is to assure the soundness of this general purpose scientific establishment. One way it does this is to assure support for all the science areas basic in nature, from which we know will come in time the research insights and developmental opportunities that then become useful to the mission-oriented agencies.

Mr. VIVIAN. I asked this question not for the purpose of giving you a hard time but for a different reason, and that is NSF does seem to be—the phrase "balance wheel" has been used—but the phrase "filling in the cracks" seems to be somewhat more apt label. I have difficulty in seeing the relationship between NIH and NSF, and in solid state research between DOD, NASA, and NSF. Have there been any changes in NIH policy as the result of the existence of NSF? In other words, what changes have occurred in NIH policy as a result of the fact that NSF came into existence? I suppose this is complicated by the fact that your agency has changed so enormously it is hard to know which came first.

Dr. SHANNON. I think the existence of NIH (and of other mission-oriented agencies supporting science) has changed the NSF concept, rather than the other way around. NSF, as it was originally conceived, was to be the scientific establishment in the Government that would cover not only the physical sciences and mathematics but all science areas, including those relevant to health and disease. Indeed in the original report spelling out the NSF concept, there was a substantial segment assigned to the area of the medical sciences. But when NSF came into being in 1950, NIH already had established seven of its eight present categorical institutes. We already had a going program in a wide variety of research areas, both applied and fundamental; and these facts were taken into account in developing NSF programs. However, it is also true to say that the establishment of NSF indeed conditioned the further development of NIH.

Let me be quite specific about certain areas. We have an overlap, for example, in chemistry. You will find that we support about half of the chemistry and NSF supports about the other half. Moreover, this is an area where it is sometimes hard to say whether NIH or NSF should support a particular project. The chemistry we support is that which can be rationalized as relating in one way or another to the biological structures we deal with or to the ability of chemicals to influence those biological structures (the development of therapeutic agents and the like). NSF, however, in a comparable area, would be less concerned with the interaction of chemicals with biological systems than it would be, for example, in synthetic organic chemistry for its own sake. So that while chemistry is supported by both agencies, there is a sharp cleavage in general between that which we support and that which the National Science Foundation supports. It is true, though, that there is some overlap. But if there were no overlap, there would likely be a broad deficiency. I think our attitude would be that so long as the same criteria of excellence are applied by both agencies, then in this overlapped area where research grant applications can go to either agency, it probably doesn't make too much difference.

Mr. VIVIAN. My comment might be that one of our difficulties in trying to set budgets for various agencies and departments is that it is very difficult to know whether there is a proper correlation between the agencies or unnecessary duplication.

Let me ask three questions very quickly. You are probably aware of the proposed environmental sciences group or department which is an attempt to combine several other units, such as the Coast and Geodetic Survey, the Boulder Laboratories, and so on. Do you have any views which you would like to express briefly on whether or not that is desirable in the present structure or would you prefer to avoid that question?

Dr. SHANNON. From what I know of it I would say it is highly desirable. I would point out that in this area there will be a comparable type of overlap with NSF as with ours.

Mr. VIVIAN. That is correct.

Dr. SHANNON. There could also be some overlap between this new structure and the environmental sciences programs of the Public

Health Service which seek solutions to problems of hostile environment such as water pollution, air pollution, and the like.

Mr. VIVIAN. Who supports psychologists? I suppose the psychiatrists are supported by NIH.

Dr. SHANNON. I think we support the largest segment.

Mr. VIVIAN. You do clearly support psychologists as psychologists?

Dr. SHANNON. Yes, sir.

Mr. VIVIAN. Does NSF?

Dr. SHANNON. I am sure they support psychology.

Mr. VIVIAN. I would appreciate some knowledge of what projects are conducted in this area.

The neurology of the brain is related to the biochemistry of the brain. Is there a major program which I will call the phenomenon of the human brain in which all of the informational sciences are applied to the subject, is this an active subject in your Institute at the present time?

Dr. SHANNON. Yes, sir; it has two primary poles around which the programs develop. One is the Brain Institute developed under the auspices of UCLA. This is an interesting institute because it is almost exclusively supported by Government; I think to the point of about 95 percent. We can get precise figures if they become important.

Mr. VIVIAN. I wonder if you could provide me with some material on this either in written form or by having some person come to my office at sometime in the near future?

Mr. DADDARIO. I think it would be helpful if you could provide that for the record. I am interested in further information on the Brain Research Institute. I visited it a few years ago as it was being formed, and it would be helpful for the record if we could see what kind of contribution it has made in view of the question and the remarks you have made.

(The information requested is as follows:)

The Brain Research Institute of the University of California at Los Angeles began to take shape in the early fifties under the leadership of Dr. H. W. Magoun. He encouraged members of many different departments interested in the nervous system to develop closer relationships, so that they might become more effective; also to broaden the scope of their investigative activities. This endeavor eventually resulted in institute status being assigned by the University of California late in 1959. A building to house the research projects was constructed and occupancy began in March 1961. The structure contains 76,000 square feet of space. The official opening of the Brain Research Institute was held on October 14 and 15 in 1961.

The Brain Research Institute operates under a director and an advisory committee appointed by the chancellor upon recommendations of the dean of the medical school. Members of the Brain Research Institute are elected by action of the advisory committee and director in recognition of their established capability in brain research as indicated by their research accomplishment. During the period July 1, 1963, through June 30, 1964, there were 68 members, 10 associate members, 12 visiting members, and 5 consulting members of the institute. These were from 14 departments, 12 of which were in the school of medicine, and 2 from the college of letters and sciences. (All members of the institute must be members of some department of the university.) In this capacity all the academic members (appointments at the level of assistant professor or higher) are able to assume some teaching responsibilities in the undergraduate medical students and graduate divisions. Some have less teaching responsibility than others depending upon their position in the school. However, all members of the institute devote their main research effort toward the advance of knowledge in function and structure of the brain.

The efforts of the Brain Research Institute, which cross many disciplinary lines, may be grouped under three headings: (1) "Project Research," (2) "Program Research," and (3) "Research Training."

"Project Research" is research carried out by an individual investigator; there are some 114 of these projects covering almost all biomedical disciplines.

"Program Research" is used to describe interdisciplinary research activities involving several investigators from more than 1 to as many as 14 separate departments. Common among these programs are the Brain Information Service, the Cardiovascular Research Laboratories, the Clinical Neurophysiological Unit, the Data Processing Laboratory, Marine Biology Laboratory, the Space Biology Laboratory, and the Visiting Scientist Program.

The "Research Training" programs train investigators for independent careers in research. These investigators are at all levels of professional development and are subject to the interdisciplinary activities which characterize the entire institute. The curriculum sponsored by the institute emphasizes both formal disciplinary science education and less formal seminars and lectures. There is a special training committee which is responsible for coordinating education in the program with departmental requirements for the trainees. University departments represented on this committee generally include all of the biological sciences (though botany may be an exception).

The source of funding for the Brain Research Institute is as follows: 3 percent from the State, 4 percent from private foundations, 57 percent from NIH, and 36 percent from other Federal agencies. The budgetary allocation is 84 percent for research, 9 percent for training, and 7 percent for fellowships and facilities. The breakdown of this data is given on three tables copied from the 1964–65 annual report of the Brain Research Institute.

TABLE I.—*Brain Research Institute funding*

	Number grants	Amount
Grants to BRI members		$4,821,716
National Institutes of Health:		
A—Arthritis and Metabolic Diseases	4	110,677
B—NINDB	36	1,450,270
C—Cancer	2	60,121
H—Heart	7	160,637
M—NIMH	14	790,183
Other NIH	8	156,877
Total	71	2,728,765
Other grants or gifts	55	2,092,951
Total	126	4,821,716

TABLE II.—*Research and training budget of Brain Research Institute activities*

	Amount	Percent
	Millions	
Total budget	$4.82	
NIH	2.73	57
NINDB	1.45	53
NIMH	.30	30
Other NIH	.48	17
Others	2.09	43
Federal (7 sources)	1.73	83
State (3 sources)	.13	6
Private (13 sources)	.23	11
Budgetary allocation:		
Research	4.05	84
Training	.46	9
Fellowships and facilities	.31	7

TABLE III

BRAIN RESEARCH INSTITUTE

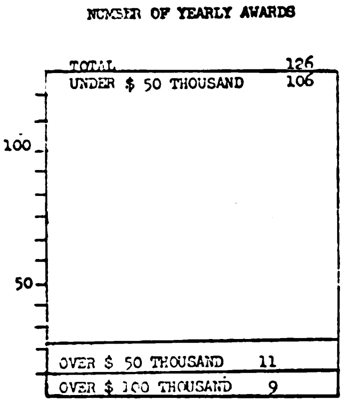

Fig. 1

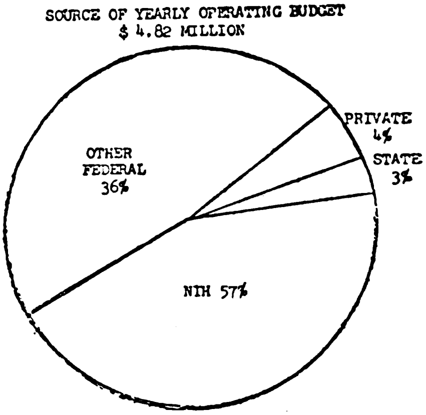

Fig. 2

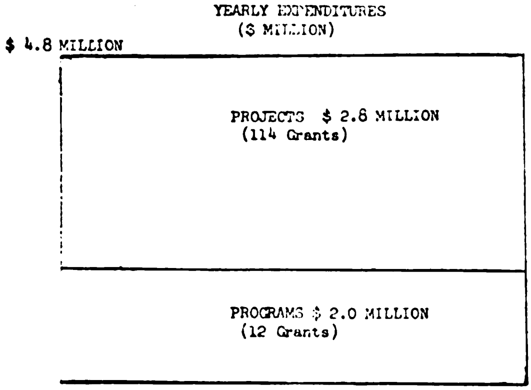

Fig. 3

Mr. DADDARIO. We do have a quorum call. I want to thank you, Dr. Shannon, and Mr. Murtaugh, too, for your wonderful contribution to this committee. I regret we do not have more time for questions, but I would like to send a series of questions to you for the record.[1]

This committee will adjourn until tomorrow morning at 10 o'clock at the same place.

(Whereupon, at 12:50 p.m., the committee was adjourned, to reconvene at 10 a.m., Thursday, July 15, 1965.)

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

THURSDAY, JULY 15, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research and Development,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. This meeting will come to order.

Our first witness is Dr. Augustus B. Kinzel, who is the president of the National Academy of Engineering, and who has been of help to this committee in the past. We are pleased to have you here this morning, Dr. Kinzel. We recognize that you have some other responsibilities this morning, so we will proceed immediately.

Dr. Kinzel. Thank you, sir.

STATEMENT OF DR. AUGUSTUS B. KINZEL, PRESIDENT, NATIONAL ACADEMY OF ENGINEERING

I have prepared a very short statement and I am, of course, prepared for questions. It is both a pleasure and a duty to respond to your invitation.

As to my qualifications:

Presently, I am vice president, research, Union Carbide Corp. At the end of this month, on reaching mandatory retirement age, I take on duties as president and chief executive officer of the Salk Institute for Biological Studies. I am president of the National Academy of Engineering and a member of the National Academy of Sciences. For the past 43 years I have worked in science, engineering, and research administration. During that time I have been consultant to and chairman or member of advisory committees to innumerable Government agencies. I have also held the presidency or chairmanship in many major engineering societies and organizations.

In commenting on the activity of the National Science Foundation, I would emphasize that science, per se, yields only knowledge. It does not, of itself, stimulate the economy nor does it, of itself, provide a high standard of living. It is the engineering step based on the new knowledge which results in directly stimulating the economy and providing the high standard of living.

Traditionally, this engineering step has been carried out by private enterprise, and the result is a tribute to its effectiveness. However, even though engineering is primarily the job of private industry, Government financial aid is essential in certain areas.

For example, when the effort is primarily for a governmental function, such as defense, Government must provide dollars for the engineering fundamentals as well as the specific engineering. In addition, there are many other areas where engineering fundamentals can be properly supplied through financial support from Government; witness, the recent meeting of the National Academy of Engineering dealt with earthquake resistant structures. Here there is no private organization large enough, or with sufficient incentive, to pay for the studies. Again, studies of fundamental properties of materials can be provided by private enterprise, but there are many materials having such special uses that private enterprise cannot justify the cost of studies. Further, there are basic engineering systems, such as the functioning of columns, rotating machinery, energy transmission by fluids, and the like, where studies of the laws of behavior would be of great benefit to all. Here, the National Science Foundation can and should play a much larger role.

The National Science Foundation has professed its intent to increase emphasis on engineering, and with respect to these figures I have a reference to the report which has been issued—yet, the proportion of its dollars directed to engineering as distinct from science is essentially unchanged and remains at a very low level. In 1964, that proportion was 11.2 percent of the total and in 1966 it is 11.8 percent. Moreover, the proportion of dollars for engineering research facilities in 1966 to dollars for total special facilities is only 3.5 percent.

Further, in 1962, total Government dollar support of the engineering sciences was 7.4 percent of the total Federal dollars for basic research and in 1965 it was 6.6 percent. When we consider that one true objective of Government support programs is to increase the economy and the standard of living rather than knowledge, per se, the proportion the National Science Foundation devotes to the support of deriving useful results from knowledge would seem to be decidedly less than best judgment would dictate. Perhaps we should not expect otherwise when we recognize that historically the Foundation is almost entirely staffed by physicists and other scientists with very few engineers.

Correlatively, a similar, if not worse situation exists with respect to engineering fellowships, particularly at the graduate level. There is a woeful lack of National Science Foundation fellowships in this area. More particularly, very few fellowships are applied to students interested in engineering design. The facts, figures, and arguments in this area should come from those directly engaged in engineering education, but I bring it to your attention as an item of major concern to the engineering profession.

To conclude, in spite of the decision to increase support of engineering by the National Science Foundation, inertia and pressure within that organization have resulted in failure to effect the desired change. This should be rectified, in my opinion, by budgetary legislation. In addition, executive action should increase counter pressures within the organizational structure and on the personnel of the National Science Foundation.

Mr. DADDARIO. Dr. Kinzel, could you amplify your last paragraph? Specifically, to what executive action are you referring? What is the

inertia pressures within NSF which have resulted in a failure to effect these changes?

Dr. KINZEL. I will attempt to so do. As you realize, we are dealing with something a bit intangible here, but I will speak to it nevertheless. The National Science Foundation is staffed almost entirely by physicists, chemists, and other scientists. It was so set up originally, historically. These men, with the best will in the world, when they apply their judgments, because of their background naturally give greater weight to things strictly scientific as distinct from the applications and the engineering. I happen to know that some of the members of the Board of the National Science Foundation have been concerned about this, but, in spite of the fact that everybody agrees that it should be done, it doesn't happen. With limited funds and many demands on these funds, the people who have their disposition at hand naturally are inclined toward that which they have been doing and which has been more or less acceptable on the one hand, and that which they are inclined to by virtue of their training. Now, I think this could be helped if topside in the National Science Foundation really made a major point of having this situation corrected and issuing either formal or informal directives to this effect.

Mr. DADDARIO. Then it is a question of emphasis on personnel who would have a tendency to support engineering rather than the sciences?

Dr. KINZEL. As far as this inertia and pressure is concerned; yes.

Mr. DADDARIO. You are the president of the National Academy of Engineering. Has this been recently organized?

Dr. KINZEL. Very recently.

Mr. DADDARIO. You are also a member of the National Academy of Sciences. Now that the National Academy of Engineering has been formed, do you think its relationship to the National Academy of Sciences and in turn to the National Science Foundation is a step in the right direction? What effect do you think this might have in bringing about the results you would like to see, insofar as emphasis is concerned?

Dr. KINZEL. It is a step in this direction, you are quite right. On the other hand, it is the kind of a step that is going to take a long time to be really effective. I think in this situation we need more timely action than you will get this way.

Mr. DADDARIO. You are looking forward to this end, but because it might prove to be rather slow, your suggestion is that a directive be issued either from the Director of the National Science Foundation, or from the executive branch or from the Congress. Is that correct?

Dr. KINZEL. That is right, to force it. That is precisely my suggestion.

Mr. DADDARIO. Mr. Roush?

Mr. ROUSH. I have no questions, Mr. Chairman.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. Would you agree that the United States has lost the world lead in applied science as opposed to basic science?

Dr. KINZEL. No.

Mr. CONABLE. Do you think that we are still preeminent in this field?

Dr. KINZEL. I do.

Mr. CONABLE. The statement has been made by some scientists appearing before us that this is a result of our emphasis on basic research. Do you think this is present also in the lack of interest by the National Science Foundation in engineering?

Dr. KINZEL. I think that has been one of the factors. I think it is less so today.

Mr. CONABLE. You feel that we still are preeminent.

Dr. KINZEL. In the engineering area; yes, I do.

Mr. CONABLE. Are we turning out engineers as fast as Russia?

Dr. KINZEL. This is a difficult question to answer because if I answer it categorically from what I know the answer would be "No," but when you say engineers you have to specify, and I would say that we are turning out a type of engineer today, certainly in the schools, let's say the top schools, a type of engineer today that is certainly the equivalent of anything that is being turned out anywhere else. As to the numbers, we don't know what we are going to need. The manpower report put out by the Killian Committee, of which I was a member, dealt with this at great length. We pointed out that some years ago, about 1952, it was predicted that there would be a terrific dearth of engineers, we just wouldn't begin to have enough, yet about 1958 they couldn't find employment and today there is no trouble hiring engineers. But the quality is the problem. There will always be a shortage of the top percent, but it helps if we can bring the whole level up, and this is what is happening actually in the schools today. In order to bring that level up, though, you must encourage the continuation of studies. That is what I was referring to in the National Science Foundation's fellowship program, which is directed almost entirely to the sciences, where engineers really have a rough time trying to find a place.

Mr. CONABLE. Thank you.

That is all, Mr. Chairman.

Mr. DADDARIO. Mr. Brown?

Mr. BROWN. Dr. Kinzel, we have been differentiating in these hearings between basic research, and applied science and engineering, although the distinction has not always been too clear. Obviously, the engineers are getting the benefit of the vast amount of money spent in applied science and engineering. The work of DOD and NASA in building hardware is where the engineers are getting the preponderance of opportunities as distinguished from basic research. Obviously, in these mission-oriented agencies we are not covering the whole gamut of engineering. I gather from your remarks that there is likely to be the same gap, in what might be called basic engineering, as there would be in science. Is this essentially correct?

Dr. KINZEL. Yes; this is absolutely correct. The mission-oriented agencies by their very nature must give support in specific areas. Now, it is certainly true as a result of their activities a great deal of engineering work is going on. But fundamental engineering is supported only in small measure here.

There is a broad area in engineering underlying all engineering philosophy and approach, and here you must have people who are free to work without having a specific mission in mind, although you must have a specific set of problems in mind. I mention here the subject of energy transmission, frequency of vibration of rotating ma-

chinery. There is a great deal that we would like to know about rotating machinery, synchronous vibrations and the like, that is a proper function for study as an item of basic engineering. And this sort of thing falls between the slots.

Mr. BROWN. Is that field called systems engineering? Is it a respectable branch of engineering or does this term cover various areas of this science?

Dr. KINZEL. To answer you first categorically, yes, it is a most respectable branch of engineering, and what is happening in the engineering world today is that with the new knowledge we have to build systems, we have to build them fast, we have to build them without the experience of the past because they are so new and the phenomena are so new and there has been no time to develop experience. The experience is still there and is still necessary with respect to all of the component parts or practically all of them, but the way in which these are put together, the way the system is built is a very high form of engineering.

Mr. BROWN. It seems to me that one essential element in the systems engineering is the identifying of problems on a large scale, which so far we have not done too well. In other words, it is not correct to simply describe it, but to recognize that there is an area of problems which by the application of appropriate technology can be solved through what we call systems engineering. It seems to me that this is an area in which more research or study is necessary at the present time.

Dr. KINZEL. You are quite right in the opportunity, but it is easier to state the fact that there is the opportunity than there is to put your teeth in it. You get hold of a problem like transportation needs in the United States, for example, you get hold of a problem like that——

Mr. BROWN. That is exactly what I have in mind.

Dr. KINZEL. As far as vehicles are concerned, highways, roadbeds, airports, these are the components of the problem, but the system is putting the whole thing together. Now, we haven't had the mechanism to set this up in the past. I think probably we are getting to it now with the changes here very recently, but along with that there will be things that require special studies. It is like a jigsaw puzzle where you have a lot of pieces but there will be a few pieces that you don't have, they have to be made, and this is where your engineering research comes in.

Mr. BROWN. And this is something you feel the Foundation should support?

Dr. KINZEL. I think the Foundation should be playing a role in this primarily because they are not mission oriented. I give a parallel in the large corporations, in some of them at least, where there is a decentralized research and development system. You have individual divisions with research laboratories working on special things. They are mission oriented, product oriented and process oriented, but in addition to that they have a small central laboratory—by small, I don't mean really small, but small in proportion to the grand total, 10 percent or something of that magnitude—where they are working on problems basic to all of the specifics, to all of the missions as it were, and this is where I visualize the National Science Foundation

in the picture, as playing that role, that is, that role in the sense of financing and guiding for the Government.

Mr. BROWN. Somewhat related to this is the application of engineering—basic engineering and basic systems engineering—to large parts of the world which are economically behind the United States. We really have a massive problem here in quickly closing the technological gap. Do you believe that there is an area of basic engineering research involved in solving this type of problem?

Dr. KINZEL. Yes, but probably a little different from what you have in mind from the way you put the statement, sir. I frequently think of engineering as the bridge between science and people. Now, you have a strong science with a bridge at one end and you have to have people that accept it at the other end. I don't think it will help very much to put a big engineering system of transportation highways and whatnot into the Congo at this time, just to pick one out of the air.

So the engineering in these developing countries has to be geared to the level of the standard of living, maybe one peg up, but not a thousandfold up. So you have a very special kind of a problem. I think that this problem requires study, but not the kind of study that I think of as fundamental engineering. It is really a study of the relationship of the economic engineering on the one hand to the level of acceptability and receptiveness of the population on the other.

Mr. BROWN. Thank you.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. On page 2 of your statement, Dr. Kinzel, there is a remark on engineering research facilities. I would like to know what you mean by engineering research facilities as opposed to research facilities in general.

Dr. KINZEL. This was taken from the Report of the Science Policy Research Division Legislative Reference Service of the Library of Congress, entitled "The National Science Foundation Agency Review of Its First Fifteen Years."

As I understand it, the way those figures were put together, and they were put together with the help of the National Science Foundation, those facilities which were specifically for scientific investigation, for example, a new accelerator or something of that kind, a Van du Graaf machine and so on, are listed as special facilities for scientific research, whereas if you had a new kind of a testing machine, coming back to the rotating machine, a stroboscope or other advanced instruments to learn more about the nature of vibration, this would be an engineering facility. Have I differentiated those?

Mr. VIVIAN. I often find them extremely difficult to differentiate. I think in education there is a great distinction, but in research facilities it is minor. Let me come back to the engineering sciences. You state that the support of engineering sciences was 7 percent in 1962. What do you mean by engineering sciences?

Dr. KINZEL. Again I take it as a direct line from this same document, and here as I understand it, the engineering sciences has to do with fundamentals of materials and fundamental behavior of structures.

Mr. VIVIAN. For example, Dr. Harvey Brooks, who I expect you probably know, was here yesterday. He is a very able and interesting person.

Dr. KINZEL. Most.

Mr. VIVIAN. He believes that engineering contains indications of theory and fluid dynamics. I happen to be a graduate engineer, and I can easily construe those as science, and it appears to me as an unanswerable argument. I believe that the distinction between engineering science and scientific engineering is a matter which is largely subjective and not objective. Therefore, I shall have to go back to the authors of those documents to which you refer to determine what they have in mind.

Dr. KINZEL. May I comment on that. Your point is very well taken, but it is like everything else where you have a gray area. We can all cite many, many things where there is no question in anybody's mind this is science and many, many others where there is no question in anybody's mind this is engineering. In between there is a gray area, and any time you have a gray area you are faced in certain specific cases with the quandry or the problem which you have just raised. But this is a small part of the grand total. I have long ago stopped letting definitions keep me from doing the job because of the 10 percent area or the 15 percent gray area that isn't covered. It is subjective, everything you have said is true, only it applies to only about 10 to 15 percent of the total areas.

Mr. VIVIAN. As an engineer, I personally feel it would be better for the National Science Foundation to have more engineers as you have suggested. Likewise, the National Academy of Sciences should have had more engineers rather than necessarily splitting into fractions.

Dr. KINZEL. May I comment on that? As far as the National Academy of Science having more engineers, because of the historic background and the way membership was put up, it couldn't be done. Many of us tried very hard to do it. This is why we set up the National Academy of Engineering, and we have set it up under the same Act of Congress under which the National Academy of Science was set up and we have set it up in such a way there will be a major degree of coordination.

Mr. VIVIAN. I hope we do not have another fraction such as a National Academy of Engineering Sciences, or a fourth academy called the National Academy of Applied Engineering.

Dr. KINZEL. Those steps are possible, but I concur in your hopes.

Mr. VIVIAN. In Dr. Brooks' remarks he said:

> In general I feel that the National Science Foundation should be cautious about entering applied science areas, and I think it should consider doing so mainly in those areas where the support of applied activities would clearly make an important contribution toward a more balanced advanced training of technologies.

I think this could also be labeled retraining as well as training. I gather that goes along with your own comments on the matter of fellowships.

Dr. KINZEL. There is nothing contradictory with what I have said at all.

Mr. VIVIAN. You would, therefore, like to have an increasing portion of the funds clearly identified for the application of science rather than the expansion of basic scientific knowledge. This comes

directly into line with the activities of Mr. Holloman's group in the Department of Commerce, which I will come back to in a few moments. The question in a sense then may not be that NSF's funds should be increased or that the funds in some other agency of the Government should be increased, but rather that the National Academy of Engineering should, perhaps, be more closely related to the Department of Commerce than to the National Science Foundation in its historic evolution.

Dr. KINZEL. May I just interject on that point?

Mr. VIVIAN. Yes.

Dr. KINZEL. I am fully appreciative of the points you have just made. The thing that we have to watch out for is that when you put certain problems into the Department of Commerce, incidentally, I am all for it, that they, too, do not become in a sense mission oriented, and the great advantage of the National Science Foundation is that there is very little chance that it will be ordered to be or designated to be mission oriented. I think this is the big difference. I am all for flexibility, too. I think that putting all your eggs in one basket, one Government agency basket, is not healthy.

Mr. VIVIAN. In view of the indicated indecision as to the gray areas I am sure there will be plenty of support which goes in all directions, somewhat like a fountain splashing off a splash plate, in fact.

I would also like your comments on this statement by Dr. Brooks:

> The National Science Foundation should in general stay out of the area of applied research except in cases where extension of its authorization to applied research would clearly contribute directly to its responsibility for the advanced education of technologists.

He was repeating the idea that NSF should stay out of engineering except in terms of training engineers.

Dr. KINZEL. I go further than that. I agree with him that it should be in the area of training. I believe it should also be in the area of fundamental engineering.

Mr. VIVIAN. What is "fundamental engineering"?

Dr. KINZEL. Those things which do not apply to a specific goal. For example, we have had this rotating machinery example, so I will stick with it. You work on rotating machinery, you don't work on a new turbine or a new pump or something of this kind, you work on the general problem having to do with all rotating machinery.

Mr. VIVIAN. I find that very hard to differentiate from science. It seems to me that engineering arises in the question of scientific knowledge in terms of which approach is better from a dollars and cents point of view or which approach is better from a health point of view or some other matter. Perhaps we should not engage in semantics. You may comment so we will come out even.

Dr. KINZEL. I have no desire to come out even. I am just trying to be helpful.

Mr. VIVIAN. Dr. Brooks also has commented:

> I feel that more use should be made of industrial scientists on the panels which evaluate engineers.

Do you feel that industrial scientists and engineers are well represented on the panels of NSF?

Dr. KINZEL. They are pretty well represented, but I think they could have better representation. This is one of the things where the National Academy of Engineering is going to work with the National Science Foundation to see if we can't help out.

Mr. VIVIAN. Another statement drawn from Dr. Brooks' remarks is:

Part of the problem of applied science is that 65 percent of all university engineering research is financed by defense and space agencies, and this has tended to orient both students and faculty away from interest in the problems peculiar to the design of products, processes, and systems where economic and political constraints are of primary importance.

I am quite familiar with this question. In a sense it is not too efficient to take individuals who have been trained in particular military applications of science where cost is somewhat secondary and to retrain them to, say, start making pots and pans, where cost is extremely important and functional performance must be very carefully geared to cost. Do you have any comments on this subject?

In other words, does the Government wisely assist in the training of technologists and engineers for commercial futures as opposed to what I will call Government futures?

Dr. KINZEL. I find it hard to differentiate. I think we are in another gray area. Let me put it this way, that the funds given by the Department of Defense and other mission-oriented agencies are generally very specifically directed, and they have to do with, in the case of training, with training people for very specific functions, not for training them and rehabilitating them in the sense of bringing them up to date and taking the college graduate of 10 years ago and seeing that he is equal to the college graduate of today, which is a different kind of an approach, and it is this second one that I think is the function of the National Science Foundation rather than one of the mission-oriented agencies.

Mr. VIVIAN. Let me switch then to another subject. One of the problems that arises in training engineers is giving experience at a design level as opposed to a study level. Again I could quote from some remarks by Dr. Brooks which I think were very intelligent on the subject, but I will refrain merely to save time.

Is there any procedure by which engineers can be trained in the realities of designing for a customer's requirements more effectively as opposed to simply learning more of the basic science of the subject?

Dr. KINZEL. I have touched on this same thing here. In the graduate work, in particular, there is a strong tendency, simply because again of the way the universities are oriented as well as the National Science Foundation, there is a strong tendency to take men that are working toward a doctor's in engineering and giving them a problem in this gray area that we are talking about that is so far over on the science side that it is almost the same kind of a thesis that the man would be working on if he were working toward a doctor of science, and actual design problems as a doctor of engineering these are very hard to find any place. Now, how to rectify this is not simple, but if a certain number of your fellowships were specifically designated for this purpose, then I think the university people would give the whole matter some more thought and you would find the thing going in that direction.

Mr. VIVIAN. Dr. Brooks pointed out that doctors have an internship period during which they proceed to administer curative measures to patients. In a sense, they practice their trade very intimately. Engineers generally do not have such an immediate opportunity in the training process specifically for the design of hardware, except as a consultant. Many persons become consultants at an early age and do design work even though their education is still progressing. Can you suggest a better way to have such a person gain design experience? I am thinking in terms of an industrial intern as opposed to a medical intern.

Dr. KINZEL. Of course, the so-called cooperative programs are not new, whereby a student spends a certain amount of time in industry. This is one effective way of doing it.

Mr. VIVIAN. Are these programs being supported by the Government to any significant degree?

Dr. KINZEL. To the best of my knowledge they are not.

Mr. VIVIAN. Do you think it would be desirable or undesirable?

Dr. KINZEL. I think it would be desirable.

Mr. VIVIAN. Despite the competitive involvement?

Dr. KINZEL. As long as they are students, I don't see any competitive involvement there.

Mr. VIVIAN. The National Academy of Sciences has a contract with the Atomic Energy Commission to evaluate the proposals for construction and the sites for a proposed new high-energy accelerator. From my point of view the design and installation of that accelerator is basically an engineering job rather than a scientific job. If the National Academy of Engineering had existed for 10 years and was a stable organization with an established membership, procedures and clientele, would you have construed this as a task that would have gone to the National Academy of Engineering rather than the National Academy of Sciences?

Dr. KINZEL. Definitely. The way we are trying to get this thing set up, and I think we have got it, between the National Academy of Sciences and the National Academy of Engineering, is when a problem comes in of this kind, no matter which academy the problem is addressed to, it will wind up in the one best qualified to render the service. I think we have got the organization and the mechanics set up now so this will happen. To answer the first question, yes, definitely what you are talking about is primarily an engineering job.

Mr. VIVIAN. One can anticipate that 10 years from now we will build a larger accelerator and by that time the National Academy of Engineering will have been an established organization. I would gather that at that time we will not have to worry about an argument between the two academies as to which should evaluate the site?

Dr. KINZEL. The only comment I can make on that is I hope to goodness we can do it in 2 years rather than 10. I think we have got a good chance of doing it.

Mr. VIVIAN. Thank you.

Mr. MOSHER. Mr. Chairman?

Mr. DADDARIO. Yes, Mr. Mosher.

Mr. MOSHER. Dr. Kinzel, it is my impression that the National Academy of Sciences frequently acts in an advisory capacity to the National Science Foundation. You are president of the National

Academy of Engineering. Does your society frequently act in that same role, or do you anticipate that it will?

Dr. KINZEL. It is so new that we haven't yet, but we certainly expect to.

Mr. MOSHER. You anticipate a growing relationship of that sort with the National Science Foundation?

Dr. KINZEL. Definitely.

Mr. MOSHER. Do you see any advantages or disadvantages in a contractual relationship whereby the National Academy of Engineering might be an operating contractor employed by the National Science Foundation?

Dr. KINZEL. In the same sense that the National Academy of Science is; yes. But in the direct sense of being a contractor to carry out a project, there it would go into the National Research Council, which is run by both academies.

Mr. MOSHER. I was thinking of a contract whereby your Academy might undertake some applied research for the National Science Foundation.

Dr. KINZEL. To take the responsibility for the applied research; yes. I am distinguishing between taking on the responsibility and actually putting up a laboratory and doing it. This we don't want to do obviously.

Mr. DADDARIO. Dr. Kinzel, in reference to the desired changes you were talking about, I asked you some questions about the types of people and organizations within the Government which might be helpful to bring about this change. I did not refer at the time, however, to the National Science Board. How do you feel it could help in bringing about these desired changes?

Dr. KINZEL. There again a large part of its membership has been drawn from the scientific world, and I think a larger representation from the engineering world would be helpful.

Mr. DADDARIO. In a sense, the same criticism you had applies there as well?

Dr. KINZEL. That is right, but to a lesser degree.

Mr. DADDARIO. Dr. Kinzel, thank you very much. You have been very helpful to this committee.

Dr. KINZEL. You are very welcome, sir.

Mr. DADDARIO. Our next witness is Dr. J. Herbert Hollomon, Assistant Secretary of Commerce for Science and Technology. Dr. Hollomon has been before this committee on several occasions. We are always glad to have you here.

STATEMENT OF DR. J. HERBERT HOLLOMON, ASSISTANT SECRETARY OF COMMERCE FOR SCIENCE AND TECHNOLOGY; ACCOMPANIED BY GORDON CHRISTENSON, ASSISTANT GENERAL COUNSEL

Dr. HOLLOMON. Mr. Chairman, I have with me Mr. Gordon Christenson, Assistant General Counsel for the Department of Commerce, who has been particularly engaged in matters having to do with science and technology, industry, economy, from a legal point of view. He is sitting beside me at the table.

Mr. DADDARIO. We are pleased to have you.

Dr. HOLLOMON. I appreciate the opportunity to appear before you to discuss the National Science Foundation, its relationship to the U.S. Department of Commerce, and the role that the National Science Foundation has played in our national life since its establishment 15 years ago.

The past one and one-half decades have firmly established this era as an age of science and technology. The fact that this time span also encompasses the entire lifetime of the National Science Foundation is, of course, no accident of history. NSF is neither the sole cause of, nor an incidental consequence of, our present strong posture in basic research and science education.

The Foundation is a logical and vital institution in our Nation's total scientific and technical resources. The record of solid achievement of the National Science Foundation has been thoroughly documented in the course of these hearings. I can only echo those general sentiments that have already been expressed.

I should like to speak today from four different vantage points in examining the role of the National Science Foundation:

First, I am responsible for the supervision of several Government Bureaus involved in scientific and technical programs.

Second, as Chairman of the Interdepartmental Committee for Atmospheric Sciences of the Federal Council for Science and Technology, I have been able to observe the National Science Foundation as it functions with respect to large national research programs.

Third, I should like to comment from the point of view of a Government official responsible, in part, for insuring the effective use of research and development in the national economy. Finally, I should like to speak as a member of the scientific and engineering community.

The Department of Commerce has enjoyed cooperative and fruitful relationships with the National Science Foundation for many years. Frequently, these activities have grown out of national research programs, under which the National Science Foundation has supported research in a wide range of institutions, including Government, universities, and nonprofit organizations.

For example, the National Bureau of Standards, the Weather Bureau, and the Coast and Geodetic Survey of my Department have participated in the International Geophysical Year, Antarctic research program, International Indian Ocean Expedition, United States-Japan cooperative science program, and the International Year of the Quiet Sun.

The National Science Foundation has also made funds available for the initiation of important new programs in the Department of Commerce, which might not otherwise have been started when the need first became apparent. As in any human endeavor, new concepts and new ideas need to have an early means of support until they are able to justify an independent status. The national standard reference data system and the clearinghouse for Federal scientific and technical information were both supported, in part, by the National Science Foundation in their early stages. These programs are now generally of broad interest and utility, and have some support on their own merits.

In addition to these formal arrangements, there is a wide range of casual, though significant, contact between the Department of Com-

merce and the analytical and funding groups in the National Science Foundation. Particularly useful are the analyses and data that describe the nature and extent of research and development in the United States. I know that these contacts and this information have benefited the Commerce Department, and thereby the Nation, and I am certain that they have strengthened the overall Federal science activities.

Although NSF does and should support broadly applicable basic research programs, there is a question in my mind as to the extent to which NSF should go beyond basic research toward the practical application of the knowledge gained.

NSF must provide support for the basic research that is later used for practical purposes. However, as progress leads to operational phases, and to work lying within the scope of existing agencies, the suitability of NSF to carry on large-scale, nationwide programs is open to question. For example, I question the role of NSF in the practical, information-gathering aspects and developmental aspects of weather modification.

I believe the assignment of responsibility to NSF in weather modification has led to a loss of initiative on the part of other agencies to develop programs leading to useful results. A special commission of the National Science Board and the Interdepartmental Committee for Atmospheric Sciences is now studying the question of the role of NSF and other agencies in this field.

The Interdepartmental Committee for Atmospheric Sciences is composed of representatives from Federal agencies with responsibilities and interests in atmospheric sciences. The agencies support research and development in the fields that are pertinent to the fulfillment of their mission responsibilities. The National Science Foundation supports research that is designed to remove the scientific limitation on our understanding of natural phenomena. In this role, it has done an excellent job in benefiting of all those that have a responsibility or requirement in the atmospheric sciences.

But there is another question that should be examined. Is it desirable for an institution devoted to the conduct of atmospheric research—in this case, the National Center for Atmospheric Research, called NCAR, at Boulder—to be wholly supported by the National Science Foundation?

Should there be an institution fully funded by NSF for the specific purpose of understanding the atmosphere? Is it wise to have a situation where proposals come to NSF from the scientific community and compete for funds with one institution which is a creature of NSF? Being fully funded, the National Center for Atmospheric Research tends to become a creation of NSF without either educational or mission responsibility. What should be the relation of the Weather Bureau to NCAR?

This question has nothing to do with the quality of the research institution performing the work. It is a question of the appropriate roles of the National Science Foundation and of the National Center for Atmospheric Research.

In meteorology, there is now, and will be in the next decade, a much larger issue. We have reached the point where we need to take a look at the way we approach research related to the atmosphere, lying at

the root of weather prediction and modification. The advancing state of knowledge, together with the increasing capacity of our scientific tools—computers and satellites, for example—may provide the possibility of long-range weather predictions, or at least predictions further ahead in time than is now possible.

In order to determine whether the large perturbations of the atmosphere—the storms of the atmosphere—persist long enough to permit long-range, accurate predictions by computer, we will need a large-scale program of worldwide weather observations over the whole globe by ships, planes, buoys, and satellites. Computer analysis of the results will determine whether, with a global network, substantially improved predictions are possible. These problems involve far-reachings scientific and technical questions. They also raise questions of a different sort, such as questions of organization, policy, and responsibility.

Should the National Science Foundation support programs like this, or should the programs be the responsibility of the agencies that will have to put the results to work? This particular program will require large sums of money and many people.

Many Federal agencies will be involved, and global scientific planning is required. This type of project proposal does not originate with an individual researcher at a university. Proposal for work of this type would hardly come from a single institution. The project will ultimately be done by many nations working together. The administrative and organizational problems will be staggering. The question is, who should have responsibility for scientific tasks of this nature? In other words, what institutions or mechanisms are necessary for projects such as this?

Finally, I should like to speak from the point of view of one who is concerned with the relationship between science and technology and the advancement of the national economy. You have heard some remarks on that subject from Mr. Kinzel.

As I mentioned before, the National Science Foundation is a keystone in our efforts to develop the Nation's scientific and technological resources. Its long-term objectives should therefore be focused on building the institutions of science, rather than on the solution of specific scientific questions.

There are really two sets of institutions involved: science, as an institution; national and international in scope, and those institutions concerned with education, training, research, and the use of science.

To build and develop science, we need to support the leading people and their programs for study, as judged by the people best able to do so—the peers of the scientists themselves. In those areas of science in which it has been active, the National Science Foundation has made this Nation's science lead the world.

In my view, however, the definition of "science" used by NSF tends to be too restrictive. Our concern, and the concern of the National Science oFundation, should be directed toward science broadly. There should be a greater concern with the science of people and their behavior, with the institutions that people create, and the interaction of people with the environment and with their society. The problems center around transportation, communications, shelter, urban society, education, industrial production, and the economy. I

believe that our misunderstanding of these matters, which derive out of our national need, is limited, by comparison with our understanding of the more conventional subjects of science.

With its broad mandate for the support of basic research and scientific and engineering education, the National Science Foundation is a logical agency to focus our national efforts in these important fields. Other agencies have begun to support mission-oriented work in these fields, but NSF efforts have been modest.

These problems are commonly thought to be the more proper domain of engineering or of social science. Although engineering is concerned with the ultimate solution to problems, there is a science that underlies the new technologies we will need for a great society. NAF's relatively small effort in these fields, incidentally, should not be too surprising. Much of the research supported by NSF originates in proposals generated by individual scientists, mainly in universities. The proposals are forwarded to Washington for evaluation by committees of the scientist's peers. The primary orientation of the scientist is to present fads in fields of study. The orientation of the committee of peers is to these same fields. The forces in this system act to continue research in the traditional framework of science.

New ways must be found to encourage and stimulate research into the basic scientific problems that underlie industrial, economic, and social problems. These studies should be carried out largely in universities, where there is presently comparatively little activity. This endeavor will require leadership and initiative by the National Science Foundation, rather than being simply responsive to proposals, since it will not come about through project proposals by scientists and engineers now engaged in these fields. There are far too few people working in these areas to generate enough project proposals for an expansion of this type of activity.

The second responsibility for institution building by NSF requires support for the institutions that teach science and engineering, that train scientists and engineers, and are concerned with the use of science. For the good of the Nation, we must provide mechanisms that broaden participation in the decisionmaking process which determines the support of science and engineering. To accomplish this end the development of a large number of institutions in all parts of the country is required. There must be a broader base of support for a greater variety of scientific subjects. The ties of scientists to their institutions and institutions to their scientific staff members must be strengthened. Many centers of excellence must be developed. The translation of science to meet the local needs of society must be encouraged.

Institutional support programs, as contrasted with project support programs, best assure that we will meet these objectives. The Congress and NSF have begun to recognize this with new institutional support programs; support for them should be expanded and strengthened.

In the 19th century, we supported science in the framework of an emerging nation to exploit its natural resources, to survey and explore the continent, and to unite a large nation with communications and transportation systems. As a result, certain specific types of science emerged.

Today, we are a complex, interdependent, urban, technology dependent, international, highly mobile society. Our economy is dependent upon science and technology. We have passed from an agricultural economy to a manufacturing economy, and we are now moving into a service-oriented economy. Consequently, our support for science should be viewed within that framework. Today, as in the past, we need to support the science relevant to our needs as well as science which expands the universe of our understanding. We must support scientists and the institutions that generate knowledge pertinent to our times. We must also produce the people and the mechanisms to put the science to work to meet present needs, for if the needs are not met, the Nation will not prosper, and the science will not be supported.

To summarize briefly, the National Science Foundation has done a remarkable job, particularly with respect to the Commerce Department, in connection with broad national research programs. In my view, NSF should not take on responsibility for applying knowledge, or for operating development programs, except in the fields of education and science information. Finally, ways must be devised which will permit NSF to support researchers and institutions concerned with the broad social, technical, and economic needs of modern America. If these things can be done, NSF will continue to play its great role in the Nation's life.

Mr. DADDARIO. Thank you, Dr. Hollomon.

Mr. Roush?

Mr. ROUSH. Dr. Hollomon, you have made a very fine presentation, and I think we all appreciate the constructive criticism you offered.

I have no questions at this time, Mr. Roush.

Mr. DADDARIO. Mr. Davis?

Mr. DAVIS. Dr. Hollomon, I believe you stated that it was normal and perhaps desirable that scientific effort is supported by the ones who would profit from the fruits of the effort.

Dr. HOLLOMON. I didn't quite say that, but I believe that is generally the case.

Mr. DAVIS. Applying that thought to the meteorological research, everybody would, of course, be interested and profit by the fruits of that research?

Dr. HOLLOMON. What I said was, I felt not who would profit by it, but who would have to put the results to work.

Mr. DAVIS. Yes; that was your phrase.

Dr. HOLLOMON. That is a little different than the fellow who profits by it. You and I profit by improvements in weather prediction, for example, but the results are put to work largely by two agencies of the Government—the Weather Bureau, on the one hand, and the Military Establishment, for their particular purposes, on the other hand. I was referring to a program which derives out of the fact that we think we can make a big advancement in weather prediction. The question I raise is, should that scientific program be the responsibility of NSF or an operating agency that finally puts the results to work? It is basic science, it is fundamental science, and it is science that has to do with understanding the whole of the atmosphere, but it derives out of practical need and its results must be judged by their utility.

The question is, how do we mount a big scientific project of this sort? Who should be responsible?

Mr. DAVIS. I cannot imagine any more universally interesting and profitable area of work than this subject. In a sense, the Weather Bureau is acting as the eyes and the communications network as to what the weather is.

Dr. HOLLOMON. To analyze how to make the prediction and to improve it.

Mr. DAVIS. I do not know any group that puts the weather to work more than, say, the Department of Agriculture or the farming industry.

Dr. HOLLOMON. Yes; on the other hand, agricultural predictions are made for the Agriculture Department by the Weather Bureau.

Mr. DAVIS. I am simply discussing the phrase "put to work." For example, the maritime industry, it puts it to work in one sense of the word.

Dr. HOLLOMON. Yes.

Mr. DAVIS. Would it be too confining, then, to put something as big as NCAR under the Weather Bureau?

Dr. HOLLOMON. I made no such suggestion.

Mr. DAVIS. I would like to know what you think.

Dr. HOLLOMON. My feeling with respect to NCAR, at least at the present time, is that it should have support from more than the National Science Foundation, and that it should be supported by many agencies of the Government, and that its support should not be uniquely the National Science Foundation's.

Mr. DAVIS. In view of the universal interest in weather, wouldn't it be necessary for it to be supported by almost every Government agency in order to come up to the ideal?

Dr. HOLLOMON. By all those who have a real interest in it. I think that would be very desirable.

Mr. DAVIS. I believe that is all, Mr. Chairman.

Mr. MOSHER. Dr. Hollomon, who should have the specific scientific responsibility for the weather program? Do you have an answer to that question?

Dr. HOLLOMON. No, sir; I do not. I don't have an answer to that question. Let me tell you what is going to be involved in such an experiment. In order to find out if we can take the next big step in the improvement in the prediction of weather, an experiment is required that will demand global observations on a 300-mile net, with measurements of six or seven levels of temperature, pressure, and wind velocity, using modern computers and so forth. This experiment will require the use of balloons, buoys, ships, and will be participated in by many countries and universities. The experiment will run 3 to 6 months. It will involve a major logistics problem.

How do we integrate all the required data? How do you get it done at the right time? How do you bring them together and analyze them? This will be a scientific experiment of broad scope, which requires, in order for it to be accomplished, essentially single management. It is not the kind of science you do in a laboratory. It is what Weinberg refers to as big science.

Mr. MOSHER. You have not said who should do this, but you have said, specifically, that in your opinion the National Science Foundation should not.

Dr. HOLLOMON. No; I have not said that. I simply raised the question, and I think it is an appropriate question for this committee to examine—should that be the kind of experiment that the National Science Foundation should fund or operate? Funding and operating do not have to be the responsibility of the same agency. The question here is, should the National Science Foundation fund it, and if they do, who is going to be the responsible agency for managing the project, or should the Weather Bureau fund for and operate the program since its purpose is to improve weather predictions.

Mr. MOSHER. Are you suggesting that this committee might make some recommendations on that subject?

Dr. HOLLOMON. I think this is a question which this committee ought to give some consideration. It should consider the philosophy which it believes NSF should follow.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Dr. Hollomon, in your paper you have stated very well some points that I have been badgering some previous witnesses about with regard to the role of the National Science Foundation regarding the solution of some of our social problems today. I am very pleased to see this. It raises a number of questions which your paper does not answer, unfortunately.

Dr. HOLLOMON. I wouldn't be presumptive.

Mr. BROWN. The bulk of the funding of the National Science Foundation goes to the support of what the witnesses for universities call basic science, but which turns out to be basic physical science—chemistry, physics, mathematics, engineering. The National Institutes of Health also fund the biological sciences and chemistry related to biology. These programs are justified on the grounds that this is pure science; this is basic research. Yet, it comes by no measure close to measuring the scope of the interests of the human mind, which is the basic concern of science. I pose this question: Suppose during World War II we hadn't developed the nuclear bomb which basically requires the extension of science in physics, chemistry, and math, but instead had developed a secret weapon which we will say involved psychology. Would not the major emphasis in the National Science Foundation today be upon the behavioral sciences and matters related to psychology, rather than physics and mathematics?

Dr. HOLLOMON. It is an "iffy" question, as you well know. I would say this, it is true that much of the motivation for the kind of science that we support in this country comes from the fact that we found that science is so dramatically useful for defense and space exploration. Much of the support comes from that general or emotional feeling.

Mr. BROWN. In other words, despite everything that we have heard and the fact that the National Science Foundation is not mission-oriented, nevertheless, the importance which it gives to the physical sciences arises out of the peculiar role which the physical sciences have been found to play in the last 20 years in matters involving national defense?

Dr. HOLLOMAN. In matters involving national defense—and health which it doesn't support—and the space effort, I think that bias exists.

Mr. BROWN. Wasn't it true that in the 19th century when this country began to support the development of science through such roundabout ways as the founding of the land-grant colleges, that the basic effort was motivated at least in part by a need to solve a national problem which was in the area of food production and agricultural research?

Dr. HOLLOMON. That is correct.

Mr. BROWN. Doesn't this then lend support to your statement that we need today to look a little more broadly at the totality of the industrial, economic, and social problems that you have indicated, and to measure our support of basic science in a broader sense?

Dr. HOLLOMON. Yes, sir; the unfortunate thing about that is because of the way science is supported in this country, the likelihood of that happening, that is, people simply making proposals to NSF, is negligible. It would be like trying to start agricultural education through the land grant college by waiting for somebody to make a proposal from an institution that didn't exist.

Mr. BROWN. This is the point I have explored with several of the witnesses who have said that we are funding proposals in the social sciences in roughly the same proportion as we are in the physical sciences. This, of course, is the very point that you are making. We are not getting sufficient proposals in these areas because our basic research effort in the universities and colleges is not geared to the present needs of our Nation and our society. We need therefore to stimulate some activity beyond what we have at present, and what we are getting under the present proposal system.

Mr. DAVIS. Would the gentleman yield on that point?

Mr. BROWN. Certainly.

Mr. DAVIS. It strikes me, and perhaps both of you will agree, that our bias in favor of the physical sciences is probably far more deep seated than we realize. For example, the dramatic advances that were made in the 19th century—in the discovery of the microscope, in the discovery of the telescope, in the usage of electricity and in the ability to put combustion or heat to work in the form of a steam engine or an automobile—all of those were results in tinkering with the physical sciences.

I think that our bias in that connection, if you want to call it a bias, is quite old and quite deep seated. I concur with both of you in your recognition that it is a bias. We should devote as much time, thought, energy, and effort toward solving some of the problems in the behavioral sciences as we do in the physical sciences.

Dr. HOLLOMON. And particularly in cooperation, because the big problems that we have before us, as I see them—urban problems, the problems of pollution, the problems of transportation, the problems of the less developed countries—are problems that have two characteristics: one is that things and people interact strongly; and the other is that they are tremendously complicated. This says, it seems to me, that you want to do two things: one, try to get more effort where things and people interact, and second, people who have an

ability to deal with complicated systems. This matter was discussed by the committee earlier. I disagree a little with Mr. Vivian when he said that one can't distinguish between engineering sciences and physical sciences. The question is one of motivation. If we are trying to understand what goes on when people and freight are moved and we try to simulate the system and to understand it, we do it because the movement of people and freight are important to us. I would call these studies engineering science. Yet the science that has to do with moving people and freight is a generalized science. On the other hand we support the understanding of the universe, the galaxies, for example, because they are there and because we have faith that if we understand them we will be better off somehow.

Admittedly many times these two kinds of work are similar. One of the reasons why Congress and others think there is duplication, is because the actual work is hard to distinguish. But, I do believe there is a science which has to do with the things that undergird the economy, such as industrial production; simulation; transportation; communication; urban development; construction of houses; construction of buildings, et cetera.

Now my point is that this kind of science—call it what you will—or this kind of inquiry, is inadequately supported.

Mr. DAVIS. I agree thoroughly with that.

Mr. BROWN. By way of rebuttal to your very cogent point about the fact that our support of basic physical science today goes deeper than its significance to national defense, I think it is obvious that within the scientific community there has been a great deal of devotion to the physical sciences. This has, as you indicated, grown up in the last 50 or 100 years.

This has led to a fractionization of science, and a specialization in science which is characteristic of our society today. In other words, we have a scientific community which is growing more increasingly specialized, particularly in the physical sciences. I question, and this is a purely philosophical question, whether this is necessarily the best way for our society to go. I think this is the problem which is raised by Dr. Hollomon's paper.

I am one hundred percent in agreement with the statement which you make on page 11, that:

Today, as in the past, we need to support the science relevant to our needs.

Mr. CONABLE. Will the gentleman yield? When he says this goes deeper than you may realize, I believe he is correct. There is an element of American conservatism here relative to the function of the Federal Government.

No one can question the function of Government in national defense. However, someone can question the function of Government in designing a better home, because this sector has been traditionally taken care of by the private side of our economy. This has resulted, perhaps, in a reluctance to put ourselves into the fields of science which may have some possible danger in relationship of the Government to the individual, as for example, the behavioral sciences. There may be some reluctance based on essential American conservatism.

Dr. HOLLOMON. I believe that to be the case. I think you make a very important point, but I think that conservative bias does exist.

But, if we had a large number of young people at our universities who were concerned and thinking about the problems of building houses or buildings—I don't mean designing a specific one that you and I are going to buy—we all would profit. They would examine the problems of people, buildings, and cities in a complex society. This would seek ways to solve the system problem, the environment problem, and the noise problem. These are science questions.

Mr. CONABLE. The point is whether or not we have this sort of emotional reaction by getting into the behavioral sciences. Apparently there is no reluctance on the part of the Government to expand its role constantly. If this is the case, then certainly we have to find ways through science to expand its role intelligently.

Dr. HOLLOMON. Right. May I give you an example of this conservatism which I think illustrates the point. It is now possible and has been possible for some time to increase substantially our ability to simulate and predict the economy, either small or large. One of the big advantages in this is the so-called input-output analysis which has been developed over the last decade. Now, the amount of support for this kind of technical work—I don't known what you want to call it again—that is, to understand how one kind of competitive system operates is small. There are many people who feel that this understanding somehow threatens the enterprise system and invades the rights of the private sector.

As a consequence, the support during the last decade for this kind of work has not grown. The last input-output analysis tables that the Commerce Department has are based on the economy of 5 or 6 years ago. The amount of work which the National Science Foundation supports, to understand the economy is negligible compared to the amount of work it supports in solid state physics. Yet this is a perfectly respectable intellectual activity. It doesn't, in my view, invade the private decisionmaking process.

Mr. CONABLE. I am not disagreeing with you, but we have to go back to our constituents and justify the expenditure of their tax money for science. If we can relate the expenditures to the space race with Russia or to national defense, we find ourselves on a lot sounder ground with a basically conservative American people than we do when we start getting over into an area which could be described as Government tinkering. This is the way I would interpret Mr. Davis' remarks, and I think it is a fairly significant thing when we are considering what the role of the National Science Foundation should be. We obviously have an obligation to lead as well as simply to reflect the basic attitudes of our constituency.

Dr. HOLLOMON. I think there is one factor which may aid in this process, and that is if an increasing amount of the funds were provided for institutional support, as the tendency is now going, then these decisions as to what you do could be made locally by the institutions and the technical people themselves. This would give you a wider variety and scope of effort if it were done in that fashion.

I make another comment. I was in the Soviet Union about 4 or 5 months ago, and the only thing that I saw there with which I had some concern was the major effort that the Soviet Union began to make about a year ago and is now making, to put computer and analysis activity to work on decisionmaking and how their economy

functions. This is the only thing I saw which I believe they are really emphasizing and they are likely to do some things which we in this country are not doing. So even in this field there is competition with the Soviets.

Mr. BROWN. I think this may be a very important aspect to emphasize here. As you have indicated, it is the basic political problem with regard to support of science in this area. We have justified such ventures in absolutely pure science, such as space exploration, on the grounds of competition with the Soviet Union. I think it may be equally valid and perhaps far more important that we have successful competition with the Soviets in the understanding of economic systems. It seems likely the Soviets are moving in the direction of recognizing the vital importance of certain aspects of the market mechanics that we don't even understand ourselves. We assume as a matter of faith that the free market is the ideal mechanism for regulating the economy. It is not so much based upon analysis as it is on faith, and there are areas in which we have slid back a little bit, to say the least.

This line of discussion leads immediately to a significant question: Under these circumstances, is it necessarily true that the National Science Foundation is the best mechanism for encouraging this type of basic scientific research, if we may describe this area as being one of basic scientific research?

Dr. HOLLOMON. I think this area is like many others in that, for very specific reasons, the various mission-oriented agencies are going to have to do some work in this field because it is essential to their missions. In the case of water resources, for example, in which there is a very complicated economic, a simulation, an analysis, and a cost problem; the agencies responsible are going to do research which they deem necessary to deal with them. However, deeper questions are involved: I think a central core of support is needed to provide the freedom, not limited by the peculiar requirements of a particular mission-oriented agency. Here we are dealing with questions, in which the industry of America, particularly in the productive process, is deeply involved. I think it is important that we do not support work which is the primary domain of a particular company, a particular product, or a particular market. A small amount relative to the whole ought to be supported, particularly in universities, to attract the attention of some of our brighter young people to these fields which, I think in the long term, are just as important as the science of chemistry, physics, biology, and mathematics.

Mr. BROWN. Purely by historical accident we have a situation where the basic health sciences, and this includes biology and medicine, are supported primarily by the National Institutes of Health. In the last 15 years, stemming from the impetus of the wartime discoveries in physics and so forth, we created the National Science Foundation, which has a "balance wheel" function in this area. What we are talking about here is sufficiently different in scope and approach that it might be desirable to start another agency whose focus would be on the relationship between science and people.

Dr. HOLLOMON. And the economy.

Mr. BROWN. And the economy.

Dr. HOLLOMON. That may well be the case. I think it presents to this committee and the Congress a very real question. Should the predominant role in this area be that of the National Science Foundation or is there need for a new kind of activity in some other agency? This requires deep consideration and thought. I believe the need is real, and it is particularly important as we look at the next 10 years or so. Unless we get at the research now, we will not be in a good position to deal with these increasingly complicated problems in the future. This committee and the Congress, in its deliberations ought to come to grips with the question of the means by which we begin.

Mr. BROWN. It might help solve the political problem, involving the desirability of governmental support of this area of basic research, to have this in a separate agency. The policy could be debated and resolved by this agency and we could look back and review how we, for instance, got into the basic support of agricultural research when agriculture is an excellent example of the free enterprise system. This program initially developed in the 19th century. If we could see the comparison between today's problems and the problems of a hundred years ago and generate the political support that would be desired, we might be in a position to move ahead much more rapidly than we have been in this area.

Dr. HOLLOMON. In agriculture the science is supported by the Agriculture Department and not by NIH or by NSF. Three things were done there: No. 1, and I think the most important, was the establishment of the land-grant colleges. Second, was the establishment of support for research at the universities, associated largely with the land-grant colleges. Third, was the development of an extension program to translate and to connect that research to the people who had to use it. I think we need all three steps to meet the modern industrial, social, and economic problems of our time. We should first establish new institutions throughout the entire country to continue to develop people and industry.

Second, we need the support for research in these fields which we have been discussing by proper mechanisms.

Third, to insure the proper means of connecting that research to the recipients, the people, the Government, the industry, by an extension type activity. A program to meet the third need as you know, Mr. Brown, is now before the House. The purpose of the State Technical Service Act is to connect the basic research in universities to industry in a way that will not interfere with private enterprise.

Mr. DAVIS. May I add one thought to what you have just said about agriculture. I think that probably the greatest accomplishment that the extension program made was selling the farmers the idea that "what was good for papa is good enough for me" is not the correct attitude. Traditionally that has been the peasant attitude in the European countries since they quit hunting animals and started raising food to gain their subsistence. Farming people have had a tremendous resistance to change throughout the history of civilization. I think the extension course is what overcame the prejudice and this basic resistance and made it fashionable for a farmer to seek the latest

innovation in farming. I would not be surprised if that isn't the one huge difference between the American farmer and the Russian farmer today.

Dr. HOLLOMON. I couldn't agree with you more. The proposal that the President has made with respect to the use of science and technology in industry throughout the country called the State Technical Service Act, now before the House and the Senate, is, I believe, a most important step with respect to this problem. It relates to the problem of Midwest industry versus the industry of the two coasts. It hopefully will aid in convincing people that we can have a free enterprise industrial system and still have it change and be adaptable to change. Hopefully, it will allow better use of the University of Illinois in Urbana or the University of Michigan, for example, to bring to the community the new things that industry requires to be alert and alive. It is the single most important thing to do, in my view and that is why I hope that the Congress will, in this session, act favorably on this particular legislation.

Mr. BROWN. I have no further questions.

Mr. ROUSH. Mr. Conable?

Mr. CONABLE. No questions.

Mr. ROUSH. Mr. Vivian?

Mr. VIVIAN. I have a series of questions, but I would first like to make a comment regarding agriculture.

Agriculture generally serves a very large number of competitors, such a large number that no one feels he is getting any particular advantage or disadvantage, whereas research done for industry often serves a very limited number of very large concerns, and these concerns represent a small number of voters but a much larger amount of economic pressure. I think there is quite a distinction to be made between supporting agricultural research and industrial research, even though I am in favor of supporting industrial research.

Dr. HOLLOMON. May I interpose?

Mr. VIVIAN. Yes.

Dr. HOLLOMON. You are quite correct about the small number of large firms in manufacturing, but increasingly manufacturing is a smaller part of the American economy. The largest part of our economy is the service industries. These are the stores, the shops that repair things, and the enterprises that provide us with all sorts of services. These industries are often small, locally oriented. They engage, as you are well aware, the larger number of workers in America. More than half, now works in those industries which tend to be small and noncompetitive in the sense that they are local and regional. The service firm in California isn't competing with the maintenance man in the city of New York. They are noncompetitive in that sense, while they are very competitive locally. I think you are quite right about manufacturing, but I don't think your statement is fully correct about the service industry.

Mr. VIVIAN. I am sure you are correct.

That would suggest some of the activities in your own Department might lean toward the service function?

Dr. HOLLOMON. Without any question.

Mr. VIVIAN. You commented on the relationship between NSF and the National Center for Atmospheric Research. That may have

been discussed while I stepped out of the room. Was it discussed at any length?

Dr. HOLLOMON. Briefly.

Mr. VIVIAN. I would like to know where it is located.

Dr. HOLLOMON. Boulder, Colo.

Mr. VIVIAN. Is it involved in the proposed reorganization within the Department of Commerce for the environmental sciences?

Dr. HOLLOMON. No, sir.

Mr. VIVIAN. It is not involved?

Dr. HOLLOMON. No, sir.

Mr. VIVIAN. It is strictly concerned with research in the atmosphere?

Dr. HOLLOMON. Yes, sir.

Mr. VIVIAN. In what obvious way would it not have close relationship to this grouping of the environmental sciences?

Dr. HOLLOMON. It has a very close relationship. I have to be very careful about that question: In what way would it not. It does have a close relation and it should have an increasingly close relation.

Mr. VIVIAN. In other words, someone not aware of the potential battles between bureaus might have concluded that it should have gone under that proposed grouping?

Dr. HOLLOMON. I am certainly not in a position to answer that question either way.

Mr. VIVIAN. Are you indicating that you feel that this organization in a sense competes for NSF funds from outside proposals?

Dr. HOLLOMON. It may tend to.

Mr. VIVIAN. Are there proposals being funded from outside which are directly parallel to this Center's activities?

Dr. HOLLOMON. No; I think you misunderstood. Let me make my thoughts clear. What I said was that the NSF completely supports NCAR, and it also supports atmospheric sciences at the universities. Since it does give complete support to NCAR I think it would, without question, feel responsible for seeing that it is in good shape. In that sense NCAR competes with proposals that come from other institutions in atmospheric sciences, of which there is a fair amount.

Mr. VIVIAN. At least there is a fair amount outside now?

Dr. HOLLOMON. Oh, yes.

Mr. VIVIAN. Is the present situation criticizable?

Dr. HOLLOMON. Not necessarily.

Mr. VIVIAN. You indicate that NSF should not take on responsibility for applying knowledge and for operating development programs, except in the fields of education and science information. I presume you included in that such things as Project Mohole and weather modification?

Dr. HOLLOMON. I have not followed the Mohole project carefully. I limited it to my own experience, I refer specifically in cases to which I have experience. I raised the question of weather modification.

I would like to defer on the question of Mohole, but I think that the National Science Foundation by the very nature of things, should continue in the role of a granting and not as an operating agency.

Mr. VIVIAN. What is the exact label for this environmental science grouping? It is not a department.

Dr. HOLLOMON. It is an administration, with a long name which we will from now on refer to as ESSA.

Mr. VIVIAN. Would that administration be a fairly logical place for the Mohole project?

Dr. HOLLOMON. I don't think I can answer that.

Mr. VIVIAN. Perhaps you would like to think that over and discuss it at a later time? On page 7, you mention the weather program. I understand the Weather Bureau has certain responsibilities, as does the armed services and NASA. I do not construe the National Science Foundation as having a major responsibility for the overall coordination of the weather program.

Dr. HOLLOMON. Right.

Mr. VIVIAN. It would seem then that they have in a sense a peripheral role as measured by dollar investment.

Dr. HOLLOMON. Not in research. Their role in research support for meteorology broadly is not peripheral, it is significant. It is larger than that of the Weather Bureau.

Mr. VIVIAN. Does the Weather Bureau have less money invested in research?

Dr. HOLLOMON. In research, yes.

Mr. VIVIAN. Do NASA and DOD have less money invested in research?

Dr. HOLLOMON. The NASA situation is complicated, as you know, by the high cost of equipment.

Mr. VIVIAN. I understand that problem.

Dr. HOLLOMON. The National Science Foundation support for meteorological research was in 1966 about $15 million per year. This support is for meteorology alone, not all atmospheric sciences. It does not include aeronomy. The Department of Defense's total was $12.8 million, and the Weather Bureau in that field was about $11 million. So the largest single supporter outside of NASA, and I will come back to that in a minute, in 1966 is the National Science Foundation. The smallest of those four agencies supporting research was the Weather Bureau. Now, NASA's large costs are because of the high hardware costs of satellite development, but it is by far and away the largest in terms of money support in research and development in meteorology.

Mr. ROUSH. Mr. Vivian, Dr. Hollomon has a 12 o'clock appointment, and we agreed to let him go as soon as possible after a quarter to that hour.

Mr. VIVIAN. Let me see if I have any other matters which I think are absolutely essential here at the moment. Yes, I want to bring up one question, and that is as follows: Do you feel that there is any possibility that through either the program which you have before Congress now or others, it will be possible to lease Federal facilities for industrial research? There are many Federal facilities which contain tremendous capital investment. The utilization varies at times from heavy to light. Has any consideration been given to leasing these facilities?

Dr. HOLLOMON. I know of no such considerations. There are no bills before Congress that I know of with which I have contact. We do have, however, one program, which we are trying to increase, at the National Bureau of Standards, particularly when it moves to its

new site in Gaithersburg. We are increasing what we call our research associate program in which an industry can put people physically on the site by joint agreement between the National Bureau of Standards and the industry. We now have about 30 such industrial associates. There are certain terms and conditions under which this is done, but essentially the industry, which does not have its own facilities, is able to utilize the NSF facilities under terms which we believe are in the public interest.

Mr. VIVIAN. I believe AEC has made the type of arrangement for dealing with nuclear materials. I would appreciate it if you could give me some information as to where industrial firms or nonprofit organizations are allowed to use Government facilities.

Dr. HOLLOMON. I will try to do that.

(Dr. Hollomon's reply, in a letter addressed to Mr. iVvian, will appear in the appendix, "Communications to the Subcommittee," of volume II of these hearings.)

Mr. ROUSH. Mr. Yeager.

Mr. YEAGER. I have a number of questions, Mr. Chairman. I would like permission to submit these to Dr. Hollomon and ask him to supply the answers for the record.[1] I would also like to submit some questions to Dr. Kinzel who appeared earlier, if that is agreeable.

Mr. ROUSH. It is agreeable with the committee.

The committee stands adjourned until July 20.

(Whereupon, at 11:55 a.m., the subcommittee was adjourned to reconvene Tuesday, July 20, 1965.)

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

TUESDAY, JULY 20, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. The meeting will come to order.

Our first witness this morning is Dr. Pendleton Herring, who is the president of the Social Science Research Council. We are pleased to have you here, Dr. Herring. Will you please proceed?

STATEMENT OF DR. PENDLETON HERRING, PRESIDENT, SOCIAL SCIENCE RESEARCH COUNCIL

Dr. Herring. Mr. Chairman, I am delighted to have this opportunity to present some comments and reflections to the committee. I don't come prepared with facts and figures to present at length, but I thought it might be helpful to talk informally on the basis of my observations and contacts with the problems of the social sciences and governmental relations over the years.

I think it might be most useful if I indicate first to the committee the four or five topics I have in mind to touch upon, and there might be questions that you may have on each of these topics as I go ahead. I would like, first, to say a few words about the social science program as I have observed it in the National Science Foundation.

I have been chairman of an advisory committee concerned with that work in the Foundation, and that has given me some occasion for following the activities there. The second topic I would like to touch upon is the broader view of social science research and the Government. There are aspects that I think are quite pertinent and give us a better sense of proportion and background as we view these problems.

The third point is how to get more stable support for social science research. It seems to me that is a very basic problem.

The fourth point is how more effectively to represent the social sciences, to get their viewpoint understood and expressed in policies that relate to these fields.

And finally, perhaps if there is time, a few remarks about the broader basis that is needed, and the significance of these fields as we look to the future, the contribution that they can make both nationally and internationally.

If that is agreeable to you, Mr. Chairman, and the committee, I will proceed in this fashion.

As I thought about appearing here informally this morning, a conversation came back to memory that took place when I was in Paris a year ago in January. I found myself at an agreeable restaurant talking to the chief official of the French Government concerned with cultural relations with Africa, and in the course of the conversation he said: "You know what we have to offer to the Africans is French; it as the key to French culture." If you have ever seen an African who has a complete command of the French language, you know what he is talking about. It is a vivid experience.

I said: "What do we have in the United States to offer these developing countries?"

And his response surprised me: "You have the social sciences."

Nobody ever said that to me in Washington. I mention it here because I think it indicates one or two things, whether you agree with the statement or not, it has this factual basis: That there is a recognition in other parts of the world that these fields are highly developed in this country and that we have something that they would like to have more of. The other factual point is that if the developing countries of the world are to develop, if they are to have a command of their economic problems and their social problems, the wilderness of human problems which they face, and must face rationally if they are to get anywhere, then they need the skills that are represented by these disciplines.

I just recount that anecdote as indicative of an atmosphere.

Let's turn back very briefly to the atmosphere when the National Science Foundation legislation was under consideration. I know you have all the facts and ample Government documentation on that, so I will offer a few personal impressions. I remember the meetings here in Washington of various of us who were interested in that legislation; the debate that took place between those who wanted to get on very much with support for science, and the effort made to present a coherent and more or less united opinion to the Congress in 1947. At that time an intersociety committee composed of 2 representatives from each of 75 learned societies where canvassed for their opinion and only 2 percent of that group felt that the National Science Foundation should be limited to the natural sciences, 49 percent thought that the social sciences should be included, and the other 49 percent took the permissive attitude that they might be included if the agency wished to do so.

Well, I cite this because it indicates that there was a pretty flexible situation at the very beginning. But by the time the agency was established—and you have the legislative history and you recall the terms of the act—by the time the agency got underway and came down here to seek its appropriations and began to adjust itself to the competing agencies in the field of science the "atmosphere" had changed a bit. You remember there is some reference to "coordination in the act," what implications did that have in terms of interagency relations. That is always a little bit of uncertainty when one agency undertakes to coordinate another agency. In other words, there was a certain tentativeness, a certain, dare I say, nervousness about what the future development of this agency was to be. And

what I say about the National Science Foundation in these early years, gentlemen, I say not in any spirit of criticism at all but rather as a commentary on our life and times, a commentary on the spirit of the 1950's and the problems that were being faced.

Well, what happened with respect to the social sciences? Nothing at first. It was some time before anyone was put on the payroll to deal with these fields. Very tentatively it was decided that while there was no distinct organizational unit for the social sciences, grants might be made in so-called convergent fields, that is to say that if either the biological and medical sciences or the mathematical, physical, and engineering science divisions had something that had a connection with the social science field, they might lend some support. It wasn't until 1956 that a program was created within the National Science Foundation, and it wasn't until 1958 that an Office of Social Science was established.

Well, by 1958, mind you, there were three people there, and in that year they made 49 grants. After 8 years, 3 people, 49 grants, and then sputnik happened, and something happened not only to this little Division in its basement offices in the NSF but something happened to the United States of America, and as you look back over those years at this midpoint in the NSF you see that it really was an awakening and in the aftermath of this realization, the junior partner, the social science activities in the NSF, began to take on a greater stature and importance. If you will excuse the informal irony, I am tempted to report that in those earlier days we used to say to one another, well, this program is concerned with the basic aspects of the social sciences, but, of course, we must keep away from race, religion, sex, and politics. We can hang our clothes on the hickory limb of science, but keep out of the mainstream of social problems. I apologize for the irony, but that reflects a bit the attitude of some of us who watched from the sidelines and wondered really was this getting on with the job.

I cite here a paragraph or two of a background paper prepared in 1960 when the Division of the Social Sciences was finally created within NSF:

When the Foundation began support of the social sciences the scope of the program was small and its emphases were not those which social sciences themselves would have chosen. Many therefore felt that the Foundation was giving scant and unsympathetic attention to their needs and was merely paying lip-service to the whole subject.

This opinion changed somewhat. These evidences of the Foundation's good faith and the durability of its intentions as well as the steadfastness with which the NSF has hewed to the line of basic sciences has had some desirable effects on the social science community.

In the first place this increased recognition has encouraged more established, prominent, and reputable social scientists to apply to NSF. Evidently they have begun to feel that the Foundation is genuinely interested in assisting in the study of social science problems and the development of research techniques, and many no longer feel it is idle or pride-risky to apply to NSF for assistance.

The second good effect of the Foundation's stance has been to demonstrate that it really means to support basic research and the development of social science rather than applied craftsmanship in social affairs or contributions to topical concerns with important social problems. In the past, many capable investigators had hesitated to invest their energies and to stake their careers in the pursuit of basic research because of the uncertainty of its support and sometimes whimsical changes in fashionable topics supported by fund-granting organizations.

I think you may catch from my emphasis, gentlemen, there is a little more in that official statement than meets the eye. It was a matter of gaining the interests and competence of the leading people in these social science fields. They didn't have to go to NSF for support, there were other channels, and it was in part a question of their status within the organization.

This was a very important if somewhat subtle consideration. One cannot gainsay the fact that these fields have been the "junior partner," and this is a matter that I think has relevance for the future, and I will come back to it later.

I do not want to create the impression that there wasn't a friendly atmosphere, particularly with the establishment of the Social Science Division. There was a growing realization within the Foundation that these fields were important and that they had a place and the creation of the Division put them on all fours organizationally with the other activities. The staff has been a devoted staff and its members have won an appreciation and understanding among their colleagues in the other divisions, often in my opinion through the sheer force of their ability, their personality, their being good members of the NSF team. While there were discouraging elements in characteristics of the beginning period, I want to emphasize that within the NSF in the last few years the curve of increased support has been the steepest curve.

If you just look back, over the appropriations, let's say the grants activated and approved since 1960, 1961 to 1965, the curve goes up each year as follows: 2 million-plus, nearly 4 million, over 7½ million, nearly 9 million, over 9 million, and in 1965 well over 10 million. So in terms of the rate of increase it has been sharp. In terms of relative support, of course, it is a very modest percentage.

That, I think, Mr. Chairman, reviews the main points I had in mind about the program within the National Science Foundation.

Mr. DADDARIO. We are pleased to have the chairman of the full committeed here with us this morning, Dr. Herring: Chairman George Miller.

Mr. Chairman, do you have any questions?

Mr. MILLER. Doctor, I want to thank you for coming here. I think that you have given us some provocative statements that will bear some thought and contribute to our examination of the National Science Foundation.

I have been concerned about the social sciences and the humanities. In this country. we can't afford to neglect these things.

Of course, being a product of the old scholastic system of education, I have always thought that education was a matter of trying to teach men to think, and that if we get him thinking, he can do a pretty good job for us.

Thank you, Mr. Chairman.

Mr. DADDARIO. Thank you, Mr. Chairman.

Dr. Herring, you say the curve of support for social sciences has gone up, but then you say that the percentage is, however, modest.

I wonder if you might analyze that a little bit further. What do you think the percentage ought to be? What shall we, as a congressional committee, be thinking about in this regard?

Dr. HERRING. Mr. Chairman, I think I could be most responsive to that if I sketched in a bit this broader picture. Would that be acceptable to you?

Mr. DADDARIO. That would be fine.

Dr. HERRING. So I wouldn't get too much concerned with detail with respect to the facts and figures on this program.

Mr. DADDARIO. Don't worry about that.

Dr. HERRING. But to respond to your broader question. I would like to say as my second point that the Federal Government is one of the very great consumers of social science talent, just historically viewed. You couldn't run the Government without economists and statisticians, labor economists, agricultural economists, experts in monetary affairs, experts in international trade, and so forth. So that point needn't be elaborated, it is perfectly obvious.

The consumption of the talent of psychologists, clinical psychologists, is essential in the work of the Veterans' Administration. There is an enormous consumption of those skills there. Our Public Health Service draws upon them, also.

The conduct of international relations, the advance of public administration, all that the universities have done to make men think, Mr. Chairman, in these fields are reflected back in the work of the Government. I don't believe any of us would argue that point. But the point in my mentioning it is to contrast the consumption of these skills with the input: What has the Government been putting into these fields? And there we come back to your basic question, Mr. Chairman, as to what has been the nature of this input.

In dollar terms, as we know from the excellent tables that have been submitted to the committee, the percentage, as we have said, is modest in relative terms. In absolute terms there have been very substantial sums of Federal money directed to these fields.

If I had the time and assistance it might be in point to look back over the actual dollar expenditures and see what those dollars went for, and I would wager that from direct experiences I have on a few occasions there has been too much money available too fast and cut off too soon. It has been a pattern of hit and run. It has been a pattern predominantly I would suggest, and here again you can check on this, but I would suggest that the largest expenditures have been in connection with mission-oriented agencies where support in social science research has been a byproduct.

I hope the committee will address its consideration to this phenomenon of mission-oriented work that as a byproduct undertakes to support basic research. I won't attempt to comment on that. In the natural sciences you can get specialists there who know about it. But when it comes to the social sciences, ever now and again you pick up the newspaper and what you are really reading about is the consequence of this kind of administration. I don't want to press that unduly. It is a problem facing the State Department and the Defense Department right now in connection with the Project Camelot, and I don't feel competent to go into that in any detail, but it is another one of these illustrations.

In the course of my years in Washington I have served in the past as a consultant to the Army, the Navy, the Air Force. I have worked

with the Budget Bureau and have been close to the National Science Foundation, and one sees there this phenomenon that I think has received inadequate attention. That is one part of this problem of how to get stable support.

In other words, in answer to your question again, Mr. Chairman, I think that it isn't the absolute sum, it is the purpose. It isn't the absolute sum, it is the conditions under which the grants are made, it is the lack of continuity, and it is the spirit in which the support is offered. And the spirit that needs to infuse these activities is the spirit of treating them as needing developmental support.

Maybe one way to bring the point rather forcibly before you would be to say that the problem in these terms is on all fours with the problem in the natural sciences.

I think that in this excellent volume prepared for the committee, "Basic Research and National Goals," there is a magnificent statement in here by Roger Ravel on the earth sciences in the Federal Government, and let me just take one paragraph and just change the references from "earth sciences" to "social sciences," and you will have the story:

> The greatest need in the social sciences is to maintain and develop centers of excellence in our universities. This can best be accomplished through university centers of teaching and basic research where social scientists and students can work together in close contact with each other and with the fundamental disciplines of economics, sociology, anthropology, political science, statistics, et cetera, and where the interplay of teaching and research can stimulate both. By underwriting the vigor and dynamism of many such centers it will increase the likelihood that new ideas and fresh viewpoints can arise.

The relationship between what we do down here and what happens back on the campuses, what happens in Ann Arbor and what happens in UCLA and what happens in Berkeley and what happens in the great universities over the country is direct and, well, I hesitate to say so, but almost determining. The distinction between public and private universities, if you look at it in financial terms, is a pretty meager distinction, and you may have some witnesses who can develop that at great length.

Well, let me conclude this point, Mr. Chairman, by saying that I think the practice of subsuming under missions and other guises support for the social sciences has certain consequences that could be further examined. There is a reason for this. I understand the reason very well indeed, and I wouldn't want, shall we say, all the protective covering to be stripped away by unfriendly hands.

But if you look across the board, you see that the National Aeronautics and Space Administration and the Department of Defense have very large sums, and some of it helps these fields; you see that excellent work has been done by an agency that we regard in the highest esteem, the Office of Naval Research, that has done wonderfully well in supporting basic work; the National Institutes of Health and the National Institute of Mental Health have contributed to these fields; but I hope the day may come when it will be possible to call things by their right names and not have to relate research in sociology, let's say, to some aspect of mental health.

Maybe the day is coming when we can take pride in the social sciences, when we can say this is a national asset, this is something that

has been developed in this country as in no other country, and we like it and we want to support it, as social science research.

May I elaborate on that just a bit?

Mr. DADDARIO. Surely.

Dr. HERRING. I thing it is a magnificent story when you consider by contrast the story of our development of these fields and the sad story across the sea. If you look back to the 19th century, you see some towering figures in social science, some great men stand forth, but why were those great men's influence, why wasn't that carried forward into this century? Whatever happened in Europe as far as Weber, Durkheim, and Pareto and the whole school of provocative thinkers about social problems?

For one thing, European universities have been and still are so tradition bound that it is exceedingly difficult to get support for new fields. I could go into that further. Changes are underway; there are exciting developments in Great Britain in relation to these disciplines but by and large the weight of tradition in European universities has held back these fields.

Now the reverse of the situation in the United States: Our universities have been experimental, they have been empirical in their approach. If the community needed something, they were there to provide it, and they could make men think about all sorts of things. If they had to think about the most mundane things, they thought about it, and they came up with ways of dealing with them. That is what has happened, of course, in the social sciences. So we have this contrast.

Another contrast, of course, is the impact of the war on European countries and greatest of all the impact of dictatorship. We benefited, of course, by the highly intelligent men who came, ousted by the dictators of Europe, and many of them were in these fields, so we were enriched by that.

But above all we have been encouraged and carried forward by the freedom to discuss and to criticize and to comment and to suggest and to experiment, not only in the natural sciences but in these fields also. So there has been a very interesting relationship between the needs of the country and what has happened in these social science fields, just as well as in the natural sciences.

For example, the depression focused men's attention on economic phenomena—there was a stirring up of thought and a response within our universities. I think back to the days at Harvard when I was surrounded by Keynesians and listened to that discourse. Like it or not, there was a stimulation to economic thought that now these many years later I think you will agree is bearing some pretty substantial fruit. That is one aspect.

Another aspect is to be seen toward the end of President Hoover's administration and his concern with social trends and the engineering approach very broadly applied. His support for the study of social trends that emerged in that great set of volumes is an illustration. With the coming of the New Deal and with the necessity of building up a more adequate administrative service, there was a concomitant interest in our universities in training for public administration.

I was in the thick of that because I was secretary for the first decade at Harvard in the Graduate School of Public Administration where we were trying to get on with the training of men for public service.

There was a wonderful spirit on the part of the Government and on the part of the academic world in getting on with that particular field.

After World War II, another illustration, as we realized that we were part of a larger world, the necessity for understanding new parts of the world became evident, and that was reflected very quickly in the development of so-called area programs in our universities.

In the Social Science Research Council, we took an active lead in bringing together people in the universities and working with the private foundations in encouraging the study whatever needed to be studied about major areas of the world. In those days one of the things that needed attention, and needed it badly, was the Soviet Union, and there were some social scientists bold enough to want to find out what the Russians were doing and how Russia is ruled, despite the fact that in those benighted days some people thought even to take an interest in the Communist world was a somewhat questionable undertaking.

Well, I could go on at great length, but the point I would like to register with the committee is the relative rapidity with which you can win a response in these fields. For example, Africa was indeed a Dark Continent as far as this country was concerned in 1947, but where there is a sense of purpose and destination and reasonable financial support and national need, you can win a response with relative speed if you keep at it steadily.

I mean by "relative speed," say, 10 years. What is 10 years in areas as important as this? Indeed, it seems a little ironic that the number of people now interested in Africa almost threatens to be an embarrassment of riches because there is a limit to the number of African officials available to talk to the many specialists that turn up over there from the "developed" countries. Leaving that point aside, the fact is that we have extraordinary human resources, we have in the United States an academic community and university system that is responsive and responsible when it comes to meeting opportunities to serve the Nation.

Mr. Chairman, that is the third point I had in mind. The other point I would like to go on with raises the question of how to provide for a representation of social science needs. If you would like me to continue with that, I will do so.

Mr. DADDARIO. Please.

Dr. HERRING. I think this is a very relevant problem area for the committee. What pattern is most appropriate for insuring representation of the social sciences? If you call it a pattern, the present situation is rather kaleidoscopic. You see a variety of agencies, a variety of sources of funds, a variety of motivations, a variety of policies and occupations, and, except for the NSF and one or two other exceptions perhaps, it is very difficult to clearly envisage the relationship between the social sciences and the Federal Establishment.

Now the National Science Foundation has the charge to foster basic research. They have been supporting the social sciences, they have broadened their coverage recently so they have taken in political science as still another discipline, and one way to envisage the future would be to say, all right, let's broaden the base within the National Science Foundation still further. I know there is a friendly attitude

on the part of those running the organization, and a broadening of NSF jurisdiction is a distinct possibility to keep in mind. It does mean that what I refer to as the "junior partner" relationship is present.

One doesn't want to overstress it, but it is a part of that picture. By way of contrast, and here I am just contrasting, I am not recommending, but by way of contrast, let me present to you something that I find of great interest. Here is the report of the Committee on Social Studies under the chairmanship of Lord Heyworth, the report presented to Parliament by the Secretary of State for Education and Science, by the command of Her Majesty, June 1965. It has been very interesting to be in touch with Lord Heyworth and his staff about this development. The British, as I say, have muddled along characteristically and have been very slow to do anything about these fields. But now in this present report they refer back to the so-called Clapham Committee of 10 years or more ago where there was a fear if anything was done in these fields it would lead to the establishment of "spurious orthodoxes," whatever they are. So now they take a fresh look at the situation and they come up with the finding that the overwhelming majority of both senior and junior social scientists are strongly in favor of a Social Science Research Council in Great Britain.

They note there are contract funds for many kinds of research, and that normal support can go along through the university grants committee, and that there are ways of supporting in routine fashion, in Great Britain work in these fields. But the interesting thing is that this committee, under the chairmanship, as I say, of Lord Heyworth, an industrialist, a man of affairs, a broad-gage business-statesman, in the view of his committee the problem isn't one of routine support, it is to encourage new ideas and methods and to back men of promise. It is not to accept existing ways of doing things. They hope that existing funds will go on as usual, but they envisage, as they say in this report, the responsibilities of the Social Science Research Council to be as follows: first, to provide for support for research in the social sciences, second, to keep under review the state of research in the social sciences, third, to advise the Government on the needs of social science research, fourth, to keep under review the supply of trained research workers and to contribute resources toward this training, fifth, to give special consideration to the application of research in the social sciences, and to the dissemination about research projected and completed, and sixth, to give advice to the users of research in Government, local government, industry, and so forth.

Well, I submit that is an interesting statement. I wasn't quite prepared to have the Heyworth Committee come up with anything quite so, shall I say, so dynamic. They are not satisfied with things as they are and they are pointing in a new direction.

Well, I think there is enough in development in Great Britain to give one pause and to say: "Well, what is the best way in the United States to get on with the support of these fields and to try to realize their full potentiality? Are you satisfied with their status as a kind of junior partner?" It is very pertinent to raise that question, because the Congress now has before it a bill dealing with the creation of a Foundation for the Humanities and the Arts, and there are some aspects of the social sciences that are rather closely related to the humani-

ties. Some historians regard themselves as humanists, some as social scientists. You can't draw hard and fast lines through any of these fields of learning. They always overlap. So it raises a question of public policy as to how the Government should relate its interest, its concern, its investment in these fields to this seamless web of scholarship and research. Well, I have one point that seems to me basic and that I would like to place before you. I don't come here with a blueprint, but I want to make this basic point, that with the responsibility now, that the Federal Government has assumed in supporting education and supporting research and supporting science, it would seem to me quite desirable to have a reasonably clear relationship between whatever publics you are supporting and the governmental administrative pattern that you may be setting up.

For example, the Office of Education is receiving, of course, enlarged responsibilities and substantially enlarged appropriations.

Query: Should that agency, with its enormously important responsibility for dealing with primary and secondary education, and with the variety of things it is now assuming in the higher levels of education, should that cover the whole area or how are you going to divide it up? My plea would be that we try to think of a pattern of organization on the part of the Federal Government that would be responsive to the highest levels of research, the highest levels of excellence in scholarship and science, and try to see that Federal pattern in relationship to our universities and colleges. You are dealing with different publics when you are dealing with the highest ranges of advanced training and the frontiers of inquiry, whether it is in the humanities, the social sciences, or the natural sciences. You are dealing with subleties and characteristics there that are terribly important if you are really trying to encourage the specialists in these varied disciplines. And you are dealing with another set of problems when you are looking at our schools and all the vast difficulties related to getting on in that area. I do feel that it is desirable and might very well be possible to get a better fit between these different ranges of activity.

Now, at the present time where should a voice for the social sciences be heard? I wish I knew the answer to that. It has been suggested, for example, that on the President's Science Advisory Committee there ought to be a social scientist or two. I would like to second that suggestion. I would like to see what might be done that would be useful there. I have sat with at least one panel of the President's Science Advisory Committee and was very much impressed with the close attention and the sophistication of leading scientists when it comes to questions of public policy and their readiness to really address themselves to those problems.

I think a closer relationship at that level might be useful, at least to experiment with. When it comes to the Board of the National Science Foundation, it seems to me that, if the Science Foundation is to continue, as it presumably will, with supporting the social sciences, there should be social scientists on that Board. When I say social scientists, I don't mean a college president, I don't mean someone who was a dean in the past or someone who had some indirect interest, I mean someone who is a leader in one of the disciplines. I know that creates problems of just how many you can have in a board of that sort

and so on. I don't have any easy answer there. But I do want to underscore the importance of having people with a background in these fields on the jury when the decision is made as to "who gets what," because, as you know, many decisions relating to financial matters and to research directions are made in administrative committee meetings, and there ought to be someone present who can speak for the social sciences, lest by inadvertence or for no unfriendly reason that voice isn't heard.

Mr. Chairman, I don't want to belabor the point. I think I have indicated that I think there is a problem. It doesn't admit of a terribly easy answer, but I think there are various ways in which it might be investigated further.

Mr. MOSHER. Mr. Chairman.

Mr. DADDARIO. Mr. Mosher.

Mr. MOSHER. Dr. Herring, as a lay person, I must admit I am confused concerning the extent to which the scientific method can be applied in the social sciences, and to which of the areas of the social science it can be best applied. Has the National Science Foundation in making its selection for funding social science projects used that measure as a criteria? Has it tended to select those social science projects which most obviously lend themselves to the scientific method?

Dr. HERRING. Well, the selection procedure is through screening committees. Those screening committees are composed of highly competent specialists in the respective disciplines, whether they are natural science or social science disciplines. And the judgments that are made are the judgments of those individuals who sit on those committees and make their recommendations to the officials within the agency. In other words, it is a judgment reflecting the state of the field and the opinion of a man's peers concerning the significance of his work. Now, Congressman Mosher, I respond to your question in those terms, because if one begins to try to make fine definitional distinctions, as to how scientific is this as over against that, you could become involved in a debate some aspects of it metaphysical and some semantic, that lead to questions that are unresolved now and are not likely to be clearly resolved. But if you want me to give a quick answer to your question, I would say, by and large, "Yes, they do."

Mr. MOSHER. Do you think that the research that has been done under the National Science Foundation grants is the type of research that can be confirmed by other researchers? Is this experimental in its nature, quantitative, or to what degree is it only subjective?

Dr. HERRING. I commend to your attention the excellent paper in the report to this committee by Pfaffmann, who is a social scientist. It is a very thoughtful statement and one that I found to be very interesting reading. I would say in the social sciences when it is possible to identify a question that can be answered or explored by the use of quantification, the normal practice is to proceed in that fashion. There are matters that are not susceptible to ready quantification and it would be a waste of time to attempt to do so. Certainly the spirit of the social scientist today is to be detached, analytical, objective, and to quantify when he can quantify. Gad, if you could see the interest in using computers, you would sometimes think that maybe some of our brethren had gone too far in quantifying.

Certainly, the tendency is to seek the objective and analytical line.

Mr. MOSHER. The work done by the National Science Foundation in the social science areas has been good work in your opinion?

Dr. HERRING. Yes; I think so, and generally on the side that we have just been talking about. That is the research direction they are interested in, and that is the predominant direction I would say of the social science, if you can analyze such a general group. That is the direction, yes.

Mr. DADDARIO. Mr. Roush?

Mr. ROUSH. No questions.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. No questions.

Mr. DADDARIO. Mr. Davis?

Mr. DAVIS. Dr. Herring, you pointed out what dramatic results can be obtained from efforts in a given field once the need was perceived and accepted, and once a large group of people tried to solve the problems. You gave as an example the need for economic research during the depression. How widely accepted in your opinion should the need be before you can hope for results? Are you speaking in terms of a broad consensus of acceptance by the public?

Dr. HERRING. Well, that certainly helps as a background. No, it doesn't require a broad consensus, it requires a sense of conviction, a sense of direction. If you take, for example the National Bureau of Economic Research as an illustration, there was a research bureau set up through the dedication and vision of Wesley Mitchell, who devoted his life to the study of the business cycle as an empirical inquiry: What is this thing that comes upon us at intervals like a flood and destroys all things before it? Isn't there someway in which you can get men to think about that? So he tried to get men to think about it by collecting all the statistics and all the indexes and exploring all the economic theories that are related to it.

I think that we feel a little bit more comfortable today than we did when Wesley Mitchell started when we contemplated the business cycle as an almost "natural phenomenon." That didn't take much more than support of one of the great foundations to keep it going and the genius, conviction, and leadership of a Wesley Mitchell and the people associated with him. That national bureau has people from the universities around the country associated with it, students and so on, and over time that ripple has been enlarged.

Mr. DAVIS. Then your answer is that if even one able person, if he had the conviction and the dedication, might produce substantial results. But if it were a matter that involved a substantial outlay of money, then, of course, you would have to have a broader base of acceptance. It might even become a political question.

In that connection, do you feel there is a pressing need now for added effort in the social science field?

Dr. HERRING. I do.

Mr. DAVIS. Is it broad enough to warrant substantial public funds?

Dr. HERRING. I think that it calls for public funds. As I said earlier, we already have public funds. It calls for organizational arrangements that will optimize the use of these funds. It calls for steady support over a span of time. It calls for strengthening within our universities predominantly I would say institutes or departments

where they do have a clear sense of direction in the leadership and a basis that can be built upon.

For example, I can think, without being too particular, I can think of the plight of the man heading an important research institute in any 1 of 50 universities today. He has to meet a payroll. He is on term grants. The common picture has been that he spends probably, what, a third of his time trying to anticipate how he is going to meet the payroll over the next period. That isn't any way to run a university research operation; it is wasteful of time and talent.

I just returned from a few days at one of our leading institutions in the West reviewing the research experience in that institution over the last 10 years or so. I would prefer not to identify it, and just use it as a basis for illustration. One problem there was to get enough attention and support from the leadership of the university for these fields. What happened in this particular institution was that a group of social scientists ultimately won those top positions and their departments are doing quite nicely. So that is one factor: who sits in the decisionmaking position has great influence with respect to a variety of fields. Another element in the picture was that they had to provide research conditions that would attract to that institution really top people, and to do that you have to have support for their research, and they have to have students around who are alert and interested and very able. When you get such conditions then you can begin to build one of these research situations where you can expect accelerated consequences. Well, I think, Congressman Davis, that there are indications that over the next decade because it takes time to do these things, the chances of building have never been better, the problems have never been so demanding, and we do have now, what shall I say, a nucleus.

But, Mr. Chairman, one point that should be emphasized in responding to Congressman Davis' question is the sheer phenomenon of numbers. For example, if you take all the social scientists in our social science societies and add them up, you have a figure that about equals the number of chemists in the country. In other words, there is a problem of building more careers, attracting more people to the social sciences. This pinch of numbers is felt not only nationally in dealing with the matters I have just been talking about, but also internationally when we try to respond to requests from other countries for specialists. I have recently been concerned with a review of the Fulbright program, where our council is concerned with the other research councils in the administration of grants to advanced personnel in service overseas, and the requests from other countries for specialists in these fields just can't be met.

Mr. Davis. I have one other comment. Once you leave the field of the natural or physical sciences and move over into the social sciences you have of necessity moved from a field of complete nonpartisanship where you are dealing let's say with solid-state physics to a field which of necessity involves interpersonal relationships. It seems to me before a very big effort could be mounted in the social sciences, of course, as we pointed out earlier, it would become a political question and such studies are far more politically vulnerable by people who are not especially sold on intellectual pursuits. Anyhow, it might

make success far harder to come by in the field of sociology than it would in the other sciences.

Dr. HERRING. I think that is probably so. That isn't to say that the social and political consequences of public policy that are derived from, well, take the most spectacular example, the atom bomb, don't create very real political differences among scientists and between scientists and the public. I might say parenthetically that I served as the secretary for the Atomic Energy Commission of the United Nations in 1946, and sitting there with the group trying to do something about this brought home to me very much the enormous impact of science.

Mr. DAVIS. That bomb became a sociological problem.

Dr. HERRING. That is right, and a political problem of the first order. Can you think of a bigger political problem in the world today? I can't.

Mr. DAVIS. I certainly cannot.

Dr. HERRING. And when you take the varied responses of the great scientists of the country to that question, you find that we are all human, we all have our opinions about things. One could go on with that, but it seems to me that the main point is that these social science disciplines are by their very nature, by using that word "discipline," they are efforts, they are endeavors to be analytical. And while they at times fail, the important thing is that these are deliberate rational efforts of men trying to think analytically about problems which as you say by their very nature are at times highly controversial.

Mr. DAVIS. Thank you.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Dr. Herring, in interrogating representatives from the National Science Foundation we were informed that the relative percentage of proposals funded in the social sciences is approximately the same as those funded in the physical sciences; however, the overall percentage level is probably in the neighborhood of about 5 percent. But it leaves me at a loss to understand why we aren't funding more social science basic research through the National Science Foundation. Can you offer an explanation as to why we have such a low level of support? Is it possible that these proposals may be rather large numerically, but the amount of funds required are relatively low?

What is the answer to this situation which seems to make it appear that the National Science Foundation is being equally fair to the social sciences as to the physical and health sciences?

Dr. HERRING. Well, Congressman Brown, I will offer my opinions on this. I think the question might perhaps be answered in better factual terms by those who are directly concerned with it. It would be my impression that you find in the proposals that are presented to the Foundation certain assumptions, shall we say, as to what would be more or less likely to receive a favorable response. In other words, the public impression of what the NSF policy is would be in some degree reflected in the requests that are made. As a clear impression is gained of the scope of the Foundation's program and of the receptivity of the staff there to a broadening conception, I think that situation will improve. I think you will agree in the light of the background that I have been sketching it is not too surprising that there may be certain preconceptions about what is worthwhile submitting, and these preconceptions may not be entirely accurate.

Mr. BROWN. Yes, I think this is true. As long as the National Science Foundation takes the position that it is looking at the whole broad gamut of basic research and science research and is funding a relatively equal proportion all across the line, it is more or less immune to criticism. Perhaps the criticism should be directed to the social scientists themselves for not proposing a larger number of projects which can be funded. Perhaps they should overlook the fact that admittedly the basic role of the Foundation was in the physical science to begin with but that their mandate is broad enough to cover the social sciences. Perhaps if the NSF received a large number of social science proposals that were sound and were put in the position of either having to fund them or turn them down, then this would bring the problem to a head.

Dr. HERRING. I think that is right. I have this observation to offer. The fact that the agency is predominantly concerned with the natural sciences means that very often those in charge of the social sciences have to think: "Now, what would be an equivalent?" You start off in the language, let's say, of physics, and try to find some counterpart to that in the field of sociology. Well, there again you see it is sort of twisting things to meet a pattern, and it does make for difficulties. If you take the actual figures that I have here before me, for 1965, the grants activated came to $10,279,000, that is to say the funds that were approved.

The funds requested of the division came to $34 million, and the funds granted were just over $10 million. So it is about that proportion. I think that your question brings out the point I was trying to emphasize, and I am grateful to you for it, because I don't think, Congressman Brown, it is enough to sit back and say, well, we haven't had the proposals we want, because it isn't simply a matter of writing out a proposal and dropping it in the mail; it is a much more complex thing. It goes back to the points I was making about having the situation within the university where they can formulate a grant and carry through an ambitious program if they get the money. And there again it comes to this point of personnel.

Mr. DADDARIO. Will the gentleman yield?

Mr. BROWN. Yes.

Mr. DADDARIO. You are reemphasizing, in answer to Mr. Brown's point, the ideas you stressed in regard to developmental support, continuity, and programing of this support within an agency that does not necessarily have assigned to it a mission objective?

Dr. HERRING. Yes.

Mr. DADDARIO. Does that fit properly?

Dr. HERRING. Yes.

Mr. DADDARIO. Thank you, Mr. Brown.

Mr. BROWN. I would like to go back to your original anecdote about your conversation with the French gentleman about what we could offer to Africa. The Frenchman indicated that they could offer French, which I presume means French culture as represented by the language and all those things that go into it, and that the United States can offer the social sciences. I presume you would agree that as far as Africa is concerned there isn't a great deal that we can offer in the basic sciences because in today's environment high energy accelerators or the technology of atom bombs aren't too appropriate in

Africa. The question of what we can offer in the social sciences is an intriguing one because I think this is probably what you were getting at. What they need in Africa is an understanding of public administration, of economic organization, and of social relationships of which we have a true science in the United States. What is offered by the cold war bloc, the Communist bloc, is dogma. If there is any real strength in the competition between the two systems, it would be our contribution of science to the problems that they have in these areas as contrasted to dogma which comes from the other bloc. Am I correct in this analysis?

Dr. HERRING. That would be my opinion, Congressman Brown.

Mr. BROWN. Do you feel that if this were presented in little more vigorous terms to the policymakers of this country that they could begin to see an equal relevance to social science that they attach now to physical science in the competition with the Communist bloc?

Dr. HERRING. Well, I think there is a much wider interest and appreciation of these fields now than there has been because of some of the considerations which you have named. As you were talking I was thinking of a long trip I had in Nigeria. I went there with the intent of trying to get a better impression of what the Nigerians were going to do in implementing the Ashby report. Sir Eric Ashby and an international committee had studied the educational needs of Nigeria and had come up with recommendations. I had the opportunity of trying to find out what they were going to do about it. The situation sort of reminded me of home in a way. They wanted more education, they wanted it fast, and there were a good many political overtones to the requests geographically viewed for support for education. But the point of my mentioning it here is to emphasize in dealing with these developing countries you are truly dealing with underdeveloped, and the problem of how to begin and how to come to grips with something when it is there in such an underdeveloped state is really compelling when you come right up against it. So, even with the best will in the world to get the social sciences to work in such a country requires some kind of infrastructure on their part, enough of a bureaucracy to deal with it, enough political stability to make a decision that will stick, and so on, so that while I agree that we have a good deal that we could offer if we had the people who were ready to go over there and do it in greater measure, you do truly deal with a very underdeveloped set of institutions.

Mr. BROWN. I am not so much concerned with the mechanics, which I realize are complicated, because the mechanics are really applied research. I am talking about basic social science research to understand the problem that exists here, and then to be able to transmit that problem through applied social science research to the solution of problems that face these areas. This would be, I presume, a part of these area studies. In your opinion, are we devoting sufficient resources to support of these various studies that you have mentioned, not considering whether they are basic science or applied science, but, in general, are we supporting the matter?

Dr. HERRING. In general over the long pull we have got to do much more than we are doing because of the dimension of the problem. For our own sakes we need a clear national understanding, of what our international relationships are and how we could better implement

some of our policy commitments, but, of course, there is also the need of helping to bring these other countries up to a state where we could more effectively communicate and understand each other.

Mr. BROWN. You have avoided making a direct response to the question of whether or not the National Science Foundation is the proper body for providing the increased support which you obviously feel is necessary for basic research in the social sciences. You pointed out the emphasis given in Britain to this support and the alternative mechanisms that could be offered. Do you have a recommendation as how through modification of the National Science Foundation or through allocation of this responsibility to another organization that we could adequately meet this problem?

Dr. HERRING. Well, as you can see, I am hesitant to come in with quick answers on a problem of that sort. I think, as I said earlier, that the readiness to broaden the approach, to be somewhat more inclusive, to emphasize the broader rather than the narrower approach, that attitude commends itself to me on the part of the National Science Foundation, and I think that in terms of, if you say, immediate next steps, I would say that would be a good thing.

With respect to the other problem of how best to find a voice, I think it is of sufficient complexity to warrant inviting a number of people who are well informed to think about it. I could sound off with some judgment here this morning, but I would rather not. I think it is a problem of enough depth and complexity to warrant some more fact gathering, some more discussion, to see what others who are close to it may feel may be the sound approach.

Mr. BROWN. I have no further questions, Mr. Chairman.

Mr. DADDARIO. Mr. Vivian?

Mr. VIVIAN. None.

Mr. DAVIS. Dr. Herring, there is one question that occurred to me during the questions by Mr. Brown, and that is this. I think underlying all of our science effort is the idea that there is human benefit to be gained.

Of course, if you are going to use the phrase basic science you eliminate that particular goal as being in mind because you are saying to yourself all I am trying to do is push back the frontiers of knowledge in this field. Now, awhile ago you said that you perceived that it was going to be difficult to find a way to get things accepted in Nigeria with the state of the culture that you found there. Actually, weren't you talking about social therapy as distinguished from science?

Dr. HERRING. Well, let me see if I can be precise as to what I was thinking about.

Here is a vivid experience that comes to mind that is I think germane to your question. I spent sometime at the university in Ibadan, and I visited the hospital of the medical school, a very modern hospital, and I went into the ward, and the young physician in charge said, "See those patients, most of them are in a bed for the first time in their lives. They are very well behaved. Hundreds of people come here every morning, and since we are a medical college hospital, we send one of the interns out with some aspirin and he distributes pills and then he selects, say, the hundred people that we can handle, and we need for our medical instruction purposes." I think that that

sort of epitomizes the basic question you are asking. There they couldn't be ameliorative, you see, because the problem is too enormous. Their long-range effort at dealing with the problem is to try to train enough physicians. In other words, they have to take a developmental teaching approach to the problem of medicine there because they can't handle it with the resources they have. I said to this man, well, "Why don't you train some therapists or medical aids who could do a little something by way of amelioration?"

He said, "We don't want to have a new kind of medicine man around. We don't want to break away from the standards of scientific medicine."

Well, it lingers in my mind as a rather vivid illustration of the dilemma that confronts the person who is concerned with a choice between, A, trying to apply therapy however inadequately in view of the dimensions of the need, and, B, trying to build more basically so that in the longer run, as in this instance, there would be doctors to deal with the problem and scientific medicine established.

Mr. DAVIS. You also talked about the Frenchman offering French to the Africans, and he said that the Americans could offer sociology. Was he talking about practicing sociology on the Africans or teaching the Africans the science of sociology?

Dr. HERRING. I don't know. It was one of these passing episodes. If you want me to try to interpret what sense there was in his comment, I would say that in a very profound way—and he was a very cultivated, sophisticated Frenchman—he was saying that we have this conception of French culture, with all of its style, its subtlety, its tradition, its elan, and you folks, you see, you have your more down to earth kind of factual way of trying to analyze things and you don't have the style and the excitement that you get from studying French literature, let's say, and coming to Paris to pursue it, but you do have a way of dealing with practical problems. I think that is what he was trying to say. In other words, it seems to me he was saying as you look at the Sorbonne you see one thing, as you look at the Universities of Iowa or Kansas or Alabama or Georgia or Texas you see institutions that have a way of getting into the problems of the people and working with them. That is what I got out of it.

Mr. DAVIS. I thank you. That is all.

Mr. DADDARIO. Dr. Herring, we have had you as a witness a little longer than I had intended, but I did want to let all the members have an opportunity to participate. Thank you for coming. I hope we might be able to send some additional questions to you.[1] There are a whole series of questions which have come to mind during the course of this morning's activity, and I am sure that certain members of the staff will also offer some suggestions. It has been a very interesting and helpful participation.

Dr. HERRING. Mr. Chairman, I have enjoyed it very much, and I thank you for this opportunity. If I can be helpful in any way, please call upon me.

Mr. DADDARIO. Our next witness is Mr. Herman Pollack, the Acting Director of the International Scientific and Technological Affairs of the State Department. We are pleased to have you, Mr. Pollack. My apologies for keeping you so long.

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

STATEMENT OF HERMAN POLLACK, ACTING DIRECTOR, INTERNATIONAL SCIENTIFIC AND TECHNOLOGICAL AFFAIRS; ACCOMPANIED BY DR. WALLACE JOYCE, DIRECTOR, GENERAL SCIENCE AFFAIRS; AND ROBERT F. PACKARD, DIRECTOR, OUTER SPACE AFFAIRS

Mr. POLLACK. I always welcome an opportunity to hear Dr. Herring.

Mr. DADDARIO. We are anxious to hear your statement.

Mr. POLLACK. My intention is to skim over and highlight the early part of my statement and spend a bit more time on the latter part.

(Mr. Pollack's prepared statement appears after his opening remarks.)

Mr. POLLACK. In my statement I point out that unlike most of the witnesses testifying in these hearings, I am not a scientist. I have spent 19 years with the Department of State, largely devoted to administration of the Department and the substance of foreign affairs. I call this to your attention early because I think it will illuminate the perspective with which I view the subject at hand. The statement outlines the underpinning and the characteristics of science that give rise to the interaction of science with foreign affairs. It also describes briefly the Department's organizational response to that interaction over the past 15 years. It describes the history and organization of the office with which I am associated. It points out that the function of International Scientific and Technological Affairs, I will refer to that hereafter as SCI, is to insure that the full potential of the opportunities afforded by modern science for the benefit of our foreign policy and relations is recognized and utilized by the Department. Our success in doing that is going to be determined in part by the understanding that can be created throughout the Department as to what these opportunities are. It is also going to be determined in part by the way in which the Government agencies responsible for science here are able to organize their participation in the approach to these opportunities. There are inhibitions which I think exist which I will come back to later.

I think, too, I should have pointed out or highlighted to a greater extent than I do, that one of our functions and a major function is to anticipate the kinds of political and international problems that will be posed by scientific and technological developments in a hope that we might anticipate, we might make preparations that would enable the United States and other governments concerned to deal with these problems in a more rational and sensible fashion than we otherwise would. Thus, it is probably time that we began thinking, indeed we already are, but thinking perhaps more strenuously than we now are, as to what the implications may be of current progress in the atmospheric sciences, the lack of respect for boundaries, inherent in efforts to modify weather, and the significance of this. The statement goes on to describe the involvement of the National Science Foundation in international activities and points out that the National Science Foundation does its work in the international field exceedingly well. I am now picking up, sir, on page 10. I am happy to say that the relations between the NSF and Department of State on

all of these activities are intimate and harmonious. The fact that such Foundation interests outside the United States are devoted essentially to the substance of science while the Department's concern rests with its significance abroad to our foreign policy and relations and with its implications for our position in world affairs has helped to define jurisdictions satisfactorily up to now.

As I have indicated earlier, the Department's appreciation of science's interaction with foreign policy is maturing rapidly. So, I think, is the perception of the scientist and the scientific community on the same subject. This gives rise to consideration of the future and the question of whether NSF's international role should be enlarged.

I now approach that possible inhibition that I mentioned earlier. My approach is as follows:

The nature of the world we live in is such that the successful conduct of our foreign relations and the attainment of the objectives of our foreign policy require the effective utilization of a great variety of resources. This has led in the very recent past to major international programs in the fields of information, economic assistance, and cultural exchanges.

What is it that the United States is attempting to do in utilizing these resources for foreign policy purposes? Put most simply, it is to create a broadly based working partnership of free countries engaged in mutual tasks which serve common interests and compatible objectives. In this process we must put forward our best efforts and our best resources. I submit that among these are our capability and attainments in science and technology. Yet it seems to me that we may perhaps have been hesitant to so utilize American science because of the apprehension on the part of some, perhaps many, that to use science in this way would be to identify it with political purposes and in the process destroy some of the very integrity of science itself.

This is by no means necessarily so. And it will not be so if use of science for foreign policy purposes is wisely conceived and wisely administered. As long as the scientific relationship is in of itself scientifically valuable and as long as it is administered under criteria customary to such relationships, I submit that the integrity of science is not affected. Wherever these conditions are not met, the political purpose will in fact not be attained. Although the analogy may be a poor one, it is as if we send abroad under our cultural program a second-rate artistic performer. We would get a poor press and fail to achieve the objectives sought.

Thus I am brought to the conclusion that the interests of good international science and good foreign policy are not contradictory. If for any reason they should be, then neither the scientific goal nor the policy objective is likely to be attained. It seems clear that there will be increasing opportunities in which the course of wisdom will dictate an effort to utilize scientific cooperation and scientific relationships specifically for the purposes of improving our foreign relations and for attaining objectives of foreign policy. Rather than shy away from such opportunities, it might be better to examine whether we are sufficiently well equipped to seek and to exploit them.

The effective development of such initiatives requires in the first instance that we overcome our reluctance to take them. Beyond that many things are required, including the development of greater scientific literacy on the part of the foreign policy practitioner and simultaneously greater foreign affairs literacy on the part of the scientific administrator and planner.

The implementation of programs developed as a consequence of such initiatives leads us directly to the matter of NSF's role. We have a highly organized Government and the rules under which it is managed require each department and agency to observe rather carefully the boundaries set for it. These rules are enforced by both the Congress and the executive branch. Science however is no more restricted by bureaucratic boundaries than it is by national boundaries. It may be anticipated that we will encounter frequently in the future proposals for international scientific activity or cooperation that do not readily match a bureaucratic base in our governmental structure—that involve responsibilities of two or more agencies. In situations such as this it might be desirable for the Department of State to be able to turn to an organization such as the National Science Foundation whose perspective is Government-wide for assistance, initially at least, in the conduct or coordination of the scientific content of the program.

We need also to be aware of the inhibitions to creative initiatives imposed by the hard fact that typically a domestic agency has no authority to expend funds for scientific activities designed to serve an international purpose. Domestic agencies justify their budgets in terms of domestic benefits. This pertains, in large measure, to the NSF itself.

These considerations suggest that it is timely to think again how the U.S. Government should organize itself for the effective use of its scientific resources in support of its foreign policy and what kind of legislative mandate and authority should be provided. Of possible relevance is Public Law 86–610, dated July 12, 1960, which provides, in part, authority to engage in cooperative endeavors in health research and related activities (1) to advance the status of the health sciences in the United States and (2) to advance the international status of the health sciences. Perhaps comparable authority to advance the international status of science per se should be specifically granted to the President or to an executive agency such as the National Science Foundation.

The essential point is that the effective and legitimate employment of our tremendous science resources in support of foreign policy objectives would benefit from the availability and utilization of such authority.

Dr. Haworth and I will be considering this need and related matters further in the course of the discussions we now have underway on the common interests of the National Science Foundation and the Department of State.

That concludes my formal remarks, Mr. Chairman. I will be pleased to answer any questions.

PREPARED STATEMENT OF MR. HERMAN POLLACK, ACTING DIRECTOR, INTERNATIONAL SCIENTIFIC AND TECHNOLOGICAL AFFAIRS

Mr. Chairman and members of the subcommittee, my name is Herman Pollack. Since January 1 of this year I have been Acting Director of International Scientific and Technological Affairs in the Department of State. My permanent assignment in my organization is that of Deputy Director. Unlike most of the witnesses testifying in these hearings, I am not a scientist. The 19 years I have been with the Department of State have been devoted to the administration of the Department and the substance of foreign affairs. I offer these personal remarks at the outset, since my background undoubtedly affects the perspective with which I view the subject we are discussing.

I am pleased to have been invited by this committee to participate in this comprehensive review of the National Science Foundation. Because the Department's relations with NSF are bound up with the relationship between science and foreign affairs, I shall direct my remarks first to the considerations of U.S. involvement in international science; then, I shall refer to the Department's role in this field as it relates to NSF's foreign activities, and finally I shall consider certain aspects of the future expanding international role of science to foreign policy and the possible implications of this to the role of NSF.

It has become almost a commonplace to regard science and the successful pursuit of technology as a new important dimension in the conduct of foreign affairs. The question of how and why this is so is a very proper subject of this inquiry. From the viewpoint of the Department of State first-rate science per se generates opportunities in foreign affairs. I shall return to this theme later.

In detailing the projection of U.S. science abroad two sets of considerations are involved. The scientific considerations include the following:

Science is a unity. Its limits are the universe and the capability of the human mind. Its possession of unity, universality, and independence makes it truly supranational in character. This inherent cohesive force can be facilitated or retarded by national policies, attitudes, and mechanisms. It is wise public policy to encourage and support extensive international relationships for scientists and for scientific institutions.

Scientific excellence is dispersed. It is not an exclusive national possession. Scientists' talents and capabilities and the quality of their institutions in many lands constitute a valuable resource with which we must be associated.

The geography of phenomena is global. Major areas of scientific inquiry, such as oceanography, geophysics, meteorology, and astrophysics, can be approached in meaningful form only on a global basis. A framework of international relationships is therefore essential to scientific interest and development in those areas of study.

Given the intimate connection between the advancement of science and our national welfare, the above considerations would seem to be compelling for engaging the United States in international scientific undertakings. But there are additional considerations:

Science advances U.S. foreign policy. Scientific enterprises present exceptional opportunities to enhance the prestige, leadership, and influence of the United States. They provide a means of cooperation based upon people's interest in the advancement of knowledge and in its application for the common good. They are perhaps the least controversial and therefore potentially among the most useful ties not only with the less-developed world but also with our allies, the Soviet Union, and other members of the Communist bloc.

The language of science is worldwide. Its independent intellectual expression correlates with our philosophy of free speech and free inquiry. In the long run it reduces the tyrannical control of man's mind even in the most rigid dictatorship. Lysenko's genetics illustrates the essential incompatibility of science and dictatorship.

Science is essential to strengthen the security of the United States and the free world. Capability in science and technology is a necessary base of national and military strength. International activity in this area, especially with our allies, is required in the interests of common defense and world peace.

International relationships enhance domestic programs in technical areas. National developments in technology require close relationships with related professional endeavor elsewhere in the world. Important facets of this are sup-

port of research and training abroad, particularly by and for Americans, participation in international organizations and other collaborative ventures. The products of foreign science can favorably influence the quality and productivity of our own.

I might note that every relationship abroad, including those involving science, has political content and the Department is concerned therefore. It is relevant briefly to describe the Department of State's response to the increasing impact of science upon foreign relations before treating more specifically of the interrelationship of Department and Foundation responsibilities.

Despite Benjamin Franklin's amalgamation of science and politics in his own person, the Department's professional awareness of science as an important factor in the conduct of foreign affairs has developed only recently—in parallel with the 15-year span of the NSF. Whereas the First World War brought science into general contact with governmental policy, it took World War II and its aftermath to make scientific counsel and indispensable function of foreign policy.

The Office of the Science Adviser in the Department was first created in 1951. It brought science as a facet of foreign affairs into better focus and resulted in the appointment of scientific attachés to London, Paris, Stockholm, and Tokyo. What has since become an area of the Department designated as International Scientific and Technological Affairs is currently responsible for 23 scientific and assistant scientific attachés posted to 16 major world capitals.

The attaché's principal function is to provide advice and assistance to the Ambassador in the management of problems which have significant scientific or technological content or which would be illuminated by inputs from the perspective of a scientist or engineer. The attaché keeps the Department and the U.S. Government abreast of developments in the local organization of science and technology and in governmental policy and planning for scientific research and development. The overall subject is intricate, calling for a scientist's understanding combined with a knowledge of the local scene and a feel for policy. Also typically within the purview of his office are cooperation in space matters, in the Antarctic, in scientific information, and in proposals for mutual effort in the field of public health. Other subjects for his attention are national attitudes toward OECD, NATO, and UNESCO science and their relation to U.S. views of those agencies' scientific activities. These matters and many more of scientific content represent a not inconsiderable part of the embassy's concerns. They underline, too, the point that the scientific attaché's offices are of necessity an integral part of U.S. Embassy diplomatic operations.

The assessments regarding the local science scene provided by the attaché make an important contribution to the Department's ability to formulate overall policy. For example, special insights into a nation's future position in the economic and political spectrum may be offered by analysis of its provision for student training in engineering and scientific disciplines and its investment in industrial oriented research and similar factors.

Domestically our office, familiarly known as SCI, is organized into three units. Two of these perform respectively the important functions of promoting U.S. interests in atomic energy and in space matters where they go international. The multiplying interests and repercussions abroad of other sciences are the responsibility of SCI's General Science Unit, which administers in addition the scientific attaché program.

The perception of SCI's role by the Department of State has been evolving for the past 15 years. It is evolving at this time. It is my impression that the development of this role and of the Department's understanding of the science-foreign affairs interaction is maturing rapidly. Basically, it is SCI's function to insure that the full potential of the opportunities afforded by modern science for the benefit of our foreign policy and relations is recognized and utilized by the Department, and in turn to insure that our international affairs are so conducted as to facilitate the international pursuit of scientific objectives. As does the attaché to his ambassador, SCI attempts to provide the Secretary and other principal officers with advice on the political and policy implications of subjects having technical content. We earn our bread and butter by the work we do in negotiating international agreements for scientific cooperation and in planning for and facilitating international scientific activities and programs.

SCI's Director is Chairman of the International Committee of the Federal Council for Science and Technology, the Committee on Foreign Desalting Programs and the newly formed Interagency Arctic Working Group. The Department is represented by SCI on more than a dozen interagency committees concerned with scientific subjects.

The Department's recognition of the need for greater and wider spread competence in the interaction of science and foreign affairs had led to the establishment of a science, technology and foreign affairs course last year which is now a permanent part of the curriculum at the Foreign Service Institute. Within the past few months we have identified at every embassy where a scientific attaché is not assigned a capable officer who will be specifically responsible for following the scientific scene and reporting on significant developments. There is currently under consideration a proposal for an officer exchange program in the politico-scientific field, somewhat comparable to the one now in successful operation with the Department of Defense in the politico-military field. Consideration is also being given to ways to attract more science-trained personnel to the Foreign Service examinations.

The involvement of the National Science Foundation in activities with a foreign or international component is usually justified in terms of the pursuit of its mission to advance science in the United States. Some of its programs without explicit design for foreign or international involvement include normal support programs in certain disciplines characterized by a high movement of research investigators across national boundaries as in anthropology and oceanography. A small but important number of research grants is made each year to foreign investigators, usually justified by the contribution to be made by them complementarily with U.S. efforts. The Department examines and approves these grants to assure that the action supported does not contradict foreign policy.

NSF likewise provides support for the improved collection and dissemination of scientific information. A part of that effort is understandably aimed at foreign performers—the Abstracting Board of the International Council of Scientific Unions (ICSU), The International Federation of Documentation, the British Association of Special Libraries and Information Bureaus, etc. An obvious avenue of information exchange is that of people. By its fellowship programs and travel grants the Foundation enables several hundred American scientists each year to make foreign contacts and several scores of foreign scientists to attend U.S. scientific meetings.

An obvious projection of all such activities is the large, often global experiment or concerted synoptic study in which U.S. scientists participate with their foreign colleagues; to that end the Foundation budgets for and coordinates, on behalf of the U.S. Government, programs such as the International Year of the Quiet Sun and the International Indian Ocean Expedition.

In a somewhat different category are those activities undertaken by the Foundation at the request or instigation of other entities concerned with international science including the Department of State. On behalf of several agencies it administers a program for the translation of Soviet and Eastern European scientific periodicals and books, employing for the purpose U.S.-owned excess foreign currencies. On behalf of the Agency for International Development (and using AID funds) it operates in Central and South America two programs in science education. And at the request of the Department of State it funds and administers the United States-Japan cooperative science program; coordinates and largely funds interagency projects under the 12-nation Antarctic Treaty program; administers the U.S. portion of the North Atlantic Treaty Organization (NATO) fellowships program; and provides important backstopping functions with respect to the OECD science program—arranging for appropriate substantive U.S. participation in the several programs' elements.

This partial list indicates the scope and variety of the Foundation's overseas activities. It performs these tasks exceedingly well. Its perspective is pleasingly broad and nonbureaucratic. I am happy to say that the relations between the NSF and Department of State on all of these activities are intimate and harmonious. The fact that such Foundation interests outside the United States are devoted essentially to the substance of science while the Department's con-

cern rests with its significance abroad to our foreign policy and relations and with its implications for our position in world affairs has helped to define jurisdictions satisfactorily up to now.

As I have indicated earlier, the Department's appreciation of science's interaction with foreign policy is maturing rapidly. So I think is the perception of the scientist and the scientific community on the same subject. This gives rise to consideration of the future and the question of whether NSF's international role should be enlarged. My approach to this question is as follows:

The nature of the world we live in is such that the successful conduct of our foreign relations and the attainment of the objectives of our foreign policy require the effective utilization of a great variety of resources. This has led, in the very recent past, to major international programs in the fields of information, economic assistance, and cultural exchanges. What is it that the United States is attempting to do in utilizing these resources for foreign policy purposes? Put most simply, it is to create a broadly based working partnership of free countries engaged in mutual tasks which serve common interests and compatible objectives. In this process, we must put forward our best efforts and our best resources. I submit that among these are our capability and attainments in science and technology. Yet it seems to me that we may, perhaps, have been hesitant to so utilize American science because of the apprehension on the part of some, perhaps many, that to use science in this way would be to identify it with political purposes and in the process destroy some of the very integrity of science itself.

This is by no means necessarily so. And it will not be so if use of science for foreign policy purposes is wisely conceived and wisely administered. As long as the scientific relationship is in of itself scientifically valuable and as long as it is administered under criteria customary to such relationships, I submit that the integrity of science is not affected. Wherever these conditions are not met, the political purpose will in fact not be attained. Although the analogy may be a poor one, it is as if we sent abroad, under our cultural program, a second-rate artistic performer. We would get a poor press and fail to achieve the objectives sought.

Thus I am brought to the conclusion that the interests of good international science and good foreign policy are not contradictory. If for any reason they should be, then neither the scientific goal nor the policy objective is likely to be attained. It seems clear that there will be increasing opportunities in which the course of wisdom will dictate an effort to utilize scientific cooperation and scientific relationships specifically for the purposes of improving our foreign relations and for attaining objectives of foreign policy. Rather than shy away from such opportunities, it might be better to examine whether we are sufficiently well equipped to seek and to exploit them.

The effective development of such initiatives requires, in the first instance, that we overcome our reluctance to take them. Beyond that many things are required, including the development of greater scientific literacy on the part of the foreign policy practitioner and simultaneously greater foreign affairs literacy on the part of the scientific administrator and planner.

The implementation of programs developed as a consequence of such initiatives leads us directly to the matter of the National Science Foundation's role. We have a highly organized Government and the rules under which it is managed require each department and agency to observe rather carefully the boundaries set for it. These rules are enforced by both the Congress and the executive branch. Science, however, is no more restricted by bureaucratic boundaries than it is by national boundaries. It may be anticipated that we will encounter frequently, in the future, proposals for international scientific activity or cooperation that do not readily match a bureaucratic base in our governmental structure—that involve responsibilities of two or more agencies. In situations such as this it might be desirable for the Department of State to be able to turn to an organization such as the National Science Foundation whose perspective is Government-wide for assistance, initially at least, in the conduct or coordination of the scientific content of the program.

We need, also, to be aware of the inhibitions to creative initiatives imposed by the hard fact that typically a domestic agency has no authority to expend funds for scientific activities designed to serve an international purpose. Domestic agencies justify their budgets in terms of domestic benefits. This pertains, in large measure, to the National Science Foundation itself.

These considerations suggest that it is timely to think again how the U.S. Government should organize itself for the effective use of its scientific resources in support of its foreign policy and what kind of legislative mandate and authority should be provided. Of possible relevance is Public Law 86-610 dated July 12, 1960, which provides, in part, authority to engage in cooperative endeavors in health research and related activities (1) to advance the status of the health sciences in the United States, and (2) to advance the international status of the health sciences. Perhaps comparable authority to advance the international status of science per se should be specifically granted to the President or to an executive agency such as the National Science Foundation.

The essential point is that the effective and legitimate employment of our tremendous science resources in support of foreign policy objectives would benefit from the availability and utilization of such authority. Dr. Haworth and I will be considering this need and related matters further in the course of the discussions we now have underway on the common interests of the National Science Foundation and the Department of State.

Mr. Daddario. Thank you. Mr. Vivian?

Mr. Vivian. You comment that inhibitions to create initiatives are imposed by the fact that a domestic agency has no authority to expend funds for scientific activities designed to serve an international purpose. I presume, however, that the State Department does have such control or there is no such limitations on its authority. I would like to get some idea of the scope of funds you transfer to the National Science Foundation for the purpose of stimulating peaceful scientific activities abroad. I am not interested in any funds used for other purposes.

Mr. Pollack. We transfer no funds to the National Science Foundation. There is on specific authority available to the Department of State for this purpose. I think the only amount of money that we transfer for a scientific purpose would be a small grant that we make annually to the National Academy of Sciences to purchase, as it were, en mass consultation and advice from the National Academy of Sciences on some of our international scientific programs. That is in the amount of $25,000 per year.

Mr. Vivian. I plan to come back to that momentarily. Is National Science Foundation's budget request for international activities reviewed by the State Department? How do you effect cooperation between the National Science Foundation and the State Department in the context of the National Science Foundation budget?

Mr. Pollack. I am not familiar with the way in which the National Science Foundation puts its budget together. I do not believe that their budget contains a section devoted to international activities per se, but they do consult with us on the scope and size of the Antarctic program, they, of course, are acting at our request with respect to the United States-Japan scientific cooperation program, and there would be consultation throughout on all of the international activities which I have mentioned in my statement.

Mr. Vivian. There is, however, no review, nation by nation, of the extent to which the State Department desires to have scientific activities supported by this Nation or by UNESCO or a similar organization, and the extent to which the National Science Foundation should play a role in this subject?

Mr. POLLACK. Not at this time, sir.

Mr. VIVIAN. Would you regard such a step as desirable or not?

Mr. POLLACK. I think at some point in time it would be desirable. I don't think the Department of State, at this point, nor the Foundation, either, is equipped to do this function usefully.

Mr. VIVIAN. Is there any other organization which is equipped to do so?

Mr. POLLACK. No, sir.

Mr. VIVIAN. When do you think it should have been done?

Mr. POLLACK. Several years ago.

Mr. VIVIAN. What has happened under the authority of Public Law 86–610?

Mr. POLLACK. That authority, the second part of it, which was the authority to promote the international status of the health sciences, was authority granted to the President. He has, as I understand it, not yet made a delegation. There have only been two specific instances in which he has employed this authority, and both of them involved specific action on his part. One was a program relating to a Latin American program—I think a grant to the OAS—and I can't recall at this point what the second was.

Mr. VIVIAN. In other words, whatever the benefits which Public Law 86–610 is intended to provide or the wisdom of its passage, it has not as yet had much effect on the international science?

Mr. POLLACK. That is right. The current employment of this authority is under consideration with respect to the new program that not as yet had much effect on the international scene?

Mr. VIVIAN. It does not, however, convey any authority except in the health sciences?

Mr. POLLACK. No, sir.

Mr. VIVIAN. Let me switch to a related question. You say on page 8:

> A small but important number of research grants are made each year to foreign investigators, usually justified by the contribution to be made by them complementarily with U.S. efforts.

These are NSF grants, presumably, to which you are referring.

Mr. POLLACK. Yes, sir.

Mr. VIVIAN. What total volume of funds is involved? Approximately.

Dr. JOYCE. I do not have a figure on the NSF part. We have just the military and other agencies.

Mr. VIVIAN. I was going to ask for those next.

Dr. JOYCE. Perhaps someone from NSF is here.

Mr. POLLACK. This is Wallace Joyce, who is Chief of the International Science Section in our office.

Mr. DADDARIO. Why don't you provide those for the record?

(The information requested is as follows:)

Federal obligations for basic research to foreign performers by region, country, and agency, fiscal year 1963

[Thousands of dollars]

Country	Total	DOA	DOD	HEW	AEC	NSF	Other
Total, all countries	29,610	7,425	9,006	6,099	3,483	1,575	2,022
Europe, total	11,066	2,031	5,325	2,560	286	506	358
France	1,490	211	1,053	214	12	-------	-------
Italy	1,584	570	653	209	152	-------	-------
Poland	528	523	-------	5	-------	-------	-------
Sweden	979	183	78	649	35	30	4
United Kingdom and possessions	2,860	-------	1,399	800	5	389	267
West Germany	814	49	614	52	12	-------	87
Yugoslavia	162	114	-------	48	-------	-------	-------
Other Europe	2,649	381	1,528	583	70	87	-------
Asia, total	8,360	3,522	637	602	2,910	20	669
India	3,392	2,859	20	15	-------	-------	498
Japan	3,690	131	118	514	2,910	-------	17
Pakistan	421	353	-------	4	-------	-------	64
Taiwan (Formosa)	446	131	301	14	-------	-------	-------
Other Asia	411	48	198	55	-------	20	90
Near East, total	4,156	1,872	1,106	604	62	64	448
United Arab Republic	486	84	402	-------	-------	-------	-------
Israel	3,421	1,705	687	494	52	35	448
Other Near East	249	83	17	110	10	29	-------
Africa, total	391	-------	133	142	-------	109	7
Republic of South Africa	97	-------	-------	97	-------	-------	-------
Other Africa	294	-------	133	45	-------	109	7
Australia and New Zealand	1,438	-------	449	237	101	528	123
Canada	2,352	-------	1,090	843	9	220	190
Latin America	1,569	-------	266	848	100	128	227
All other countries [1]	278	-------	-------	263	15	-------	-------

[1] Included in this group are international organizations.

NOTE.—Definition of "foreign performers": A foreign performer is defined here as a government, citizen, or organization, either profit or nonprofit, conducting research and development, financed by the U.S. Government. A foreign performer within the concept of this definition is not a U.S. agency, citizen, or organization located abroad; also, funds reported do not include payments to foreign scientists working in the United States.

Source: National Science Foundation ("Federal Funds for Research, Development, and Other Scientific Activities," vol. XIII).

Symbols:
DOA—Department of Agriculture.
DOD—Department of Defense.
HEW—Department of Health, Education, and Welfare.
AEC—Atomic Energy Commission.
NSF—National Science Foundation.

Dr. JOYCE. This report, Mr. Chairman, is provided by the National Science Foundation, and the information comes from the publication "Federal Funds for Research, Development, and Other Scientific Activities," volume 13. It is based on figures for fiscal year 1963, which is the last year for which firm material is on hand. Research and development, total abroad, $67.6 million, according to this chart, of which $19.1 million is placed by the Department of Defense, $48.5 million by other agencies, nondefense. It is broken down by regions. If you wish to have this, I can read them off.

Mr. VIVIAN. Could I ask that the information be provided in a tabulated or summary form? I would like to know what these other agencies are which utilized two or three times as much as the $19 million quoted.

Dr. JOYCE. We will have to develop that and provide it for the staff.
(The information requested is as follows:)

Federal obligations for research and development to foreign performers by region, country, and agency, fiscal year 1963

[Thousands of dollars]

Country	Total	DOA	DOD	HEW	DOS	AEC	NASA	NSF	Other
Total, all countries	67,630	7,816	19,109	20,329	7,749	3,685	5,774	1,575	1,593
Europe, Total	22,658	2,074	10,879	7,419	--------	325	1,230	506	225
France	2,027	211	1,280	524	--------	12	--------	--------	--------
Italy	2,032	613	720	515	--------	184	--------	--------	--------
Poland	1,062	523	--------	539	--------	--------	--------	--------	--------
Sweden	1,906	183	116	1,535	--------	38	--------	30	4
United Kingdom and possessions	8,812	--------	5,374	1,866	--------	5	957	389	221
West Germany	1,977	49	1,688	128	--------	12	100	--------	--------
Yugoslavia	1,044	114	--------	930	--------	--------	--------	--------	--------
Other Europe	3,796	381	1,701	1,382	--------	74	173	87	--------
Asia, total	13,989	3,569	2,877	3,244	689	2,910	90	20	590
India	4,982	2,859	20	1,605	--------	--------	--------	--------	498
Japan	4,645	131	345	1,231	--------	2,910	--------	--------	28
Pakistan	653	353	--------	236	--------	--------	--------	--------	64
Thailand	2,051	--------	1,416	37	598	--------	--------	--------	--------
Vietnam	666	--------	666	--------	--------	--------	--------	--------	--------
Other Asia	992	226	430	135	91	--------	90	20	--------
Near East, total	7,098	2,173	1,284	2,792	269	68	--------	64	448
United Arab Republic	869	224	402	215	28	--------	--------	--------	--------
Israel	5,443	1,837	865	2,206	--------	52	--------	35	448
Other Near East	786	112	17	371	241	16	--------	29	--------
Africa, total	2,517	--------	133	348	1,043	--------	877	109	7
Republic of South Africa	999	--------	--------	237	--------	--------	762	--------	--------
Other Africa	1,518	--------	133	111	1,043	--------	115	109	7
Australia and New Zealand	5,499	--------	1,427	579	--------	112	2,849	528	4
Canada	4,763	--------	2,121	2,078	--------	9	248	220	87
Latin America	6,369	--------	388	2,081	2,819	246	480	128	227
All other countries [1]	4,737	--------	--------	1,788	2,929	15	--------	--------	5

[1] Included in this group are international organizations.

NOTE.—Definition of "foreign performers": A foreign performer is defined here as a government, citizen, or organization, either profit or nonprofit, conducting research and development, financed by the U.S. Government. A foreign performer within the concept of this definition is not a U.S. agency, citizen, or organization located abroad; also, funds reported do not include payments to foreign scientists working in the United States.

Source: National Science Foundation ("Federal Funds for Research, Development, and Other Scientific Activities," vol. XIII).

Symbols:
DOA—Department of Agriculture.
DOD—Department of Defense.
HEW—Department of Health, Education, and Welfare.
DOS—Department of State.
AEC—Atomic Energy Commission.
NASA—National Aeronautics and Space Administration.
NSF—National Science Foundation.

Mr. VIVIAN. I understand from your remarks on page 8 that there is a certain amount of money spent by NSF.

Mr. POLLACK. Yes.

Mr. VIVIAN. From my earlier questioning I gathered that the State Department played a very minor role in the amount of money NSF allocated for the purposes of these grants.

Mr. POLLACK. That is correct.

Mr. VIVIAN. In other words, the NSF gets this money from the Budget Bureau, and then you people, after they have it, help them spend it. Is that a fair statement?

Mr. POLLACK. It is not quite as bad as that. But the kind of guidance we are capable at this point of providing to the NSF doesn't amount to anything terribly firm on which to build up a budget program.

Mr. VIVIAN. I would like to complement the gentleman for his willingness to be self-critical for a moment. Not all agencies are quite prepared to do so.

Let me switch to another facet of the same subject. Wouldn't this data provide guidance as to the size of the contributions to overseas science by all the agencies who are expending funds overseas.

Dr. JOYCE. That is correct. This is research and development and also for basic research.

Mr. VIVIAN. That will include both facilities as well as operating funds?

Dr. JOYCE. I assume that it does, Mr. Vivian. I will have to check this, sir, with the NSF.

Mr. POLLACK. It does not include, I know, the NASA facilities for tracking.

Mr. VIVIAN. I am not concerned with that since it is for U.S. purposes even though located overseas.

On page 6 of your remarks you state:

> Special insights into the nation's future position in the economic and political spectrum may be offered by analysis of its provision for student training in engineering and scientific disciplines and its investment in industrial-oriented research and similar factors.

I would be quite fascinated to receive a report on what I will call the consequences of the insight which apparently have been gained. Are you in a position to make any brief remarks on the insight we gained into these specific questions as it pertains to the U.S.S.R., but more particularly to China?

Are you prepared to make any predictions as to the future position of China, for example, in the economic and political spectrum?

Mr. POLLACK. No. I am not, sir; not on China. That statement was put in here to reflect some information that was acquired with respect to national programs being pursued by Great Britain, France, Germany, and one or two other European countries. It gave some indication, as one factor among many, that would give some clues as to what the scene might look like in the 1970's in Europe if the current predictions were to stay firm.

Mr. VIVIAN. The 1970's aren't very far away.

Mr. POLLACK. That is right.

Mr. VIVIAN. I would like to go to some remarks made by Dr. Rabi, a very well know and very competent person. His prediction was that within 50 years China could be the top scientific nation in the world. Do any of your experiences in the State Department support such a contention?

Mr. POLLACK. No, sir. I am not aware of the fact that we currently have enough information on hand to indicate the current programs being pursued in China would have that consequence.

Mr. VIVIAN. Can we construe the Chinese atomic program as being a copy of the other programs elsewhere such as the Russian or the French?

Mr. POLLACK. I think a great deal of credit is to be given to the assistance they have obtained from the Soviet Union in their program.

Mr. VIVIAN. Did not the Soviet Union cut this off 6 or 8 years ago very drastically and very intentionally?

Mr. POLLACK. Yes.

Mr. VIVIAN. Then, have the Chinese progressed on their own since that time?

Mr. POLLACK. I am certain they have.

Mr. VIVIAN. I understand—and I am going entirely by unclassified literature——

Mr. POLLACK. That is all I am referring to.

Mr. VIVIAN (continuing). That the Chinese atomic bomb was of a fairly advanced type. Doesn't this suggest that their scientific progress may be fairly great?

Mr. POLLACK. It does, indeed, and I am not underestimating their scientific progress. What I am stating is that I am unaware of any basis now for making a rather firm quantitative prediction as to where they will stand 50 years hence.

Mr. VIVIAN. In the late 1940's the United States was convinced that Russia was a scientific ignoramus. I am very concerned that we as a nation are grossly underestimating the competence of China in the scientific field. I think Japan is a classical example of what can and has been accomplished by a nation with a very similar type of intellectual background. I think it is something for us to be interested in for positive reasons as well as negative. It is a source of confidence in the future as well as apprehension. I am somewhat concerned about the lack of knowledge on the subject.

I would like to read a paragraph from a letter from Mr. Nagel, Director of the External Research Staff of the Department of State—this is very brief—in response to a letter of mine.

I have recently heard from Mr. Bundy about your request for information about research in population growth and economic trends in Communist China. The amount of research in the relationship of population growth and other economic factors is very limited. As Mr. Bundy may have written you, the principal reason for the small amount of work in this field is the inadequacy of statistical information gathered by the Chinese Government.

I'm tempted to stop at that point because I think it makes an interesting stopping point. I suppose we could always send them a letter and ask them to gather more statistical information. Mr. Nagel's letter continues:

Another reason suggested by experts is the difficulty of making predictions on the Government's vacillating policy toward birth control.

I will stop reading the letter at this point except to say it lists a series of papers that have been written under various sponsorships.

I think that we can make many small policy errors in State Department affairs, and I say small even in the context of whether we should put another 20,000 troops in Vietnam, compared with the enormous errors we can make if we underestimate the capability of 600 million Chinese to develop scientifically. That is an error beyond any which we have been talking about. Having spent the last several hours this morning with Secretary Rusk, I am relatively up to date on this.

I cannot underestimate my own concern with this subject. I think it is very important that we extend some type of cooperative and helping hand to China in connection with scientific research, not research on weapons, but basic research that is of interest to scientists everywhere.

I see no evidence of this being done anywhere. Rather, I see evidence of alienating the Chinese scientific community, which I think in the long run would be an enormous mistake.

I will let go of that particular subject for a moment.

The policy control which exists in international organizations by the State Department is of interest to me. I have many acquaintances in the scientific community that serve on various international committees. Every type of scientific discipline has some international scientific committee. I have at times been unable to discern whether these individuals went to these committee meetings as, what might be called, international citizens representing their particular scientific discipline, or whether they went as representatives of the U.S. Government, or whether they were acting under State Department instruction.

Are there any rules which guide the behavior of such individuals at international conferences?

Mr. POLLACK. I think as a general rule, to which there may be some specific exceptions, that when we send representatives to an agency of the United Nations or one associated with it, which is receiving its support from congressionally appropriated funds, that our participation in this agency, the definition of the program which we will support and so on are a consequence of governmental decisions.

Now we also support participation in meetings of the international Council of Scientific Unions by providing funds for the travel of some participants and Government funds I think are used by the National Academy of Sciences to pay the dues in this organization. Scientists who attend these meetings do not attend them as Government representatives. They attend them as qualified U.S. scientists in a particular field. I am not aware of any governmental instructions being issued to these people or any requirement on their part that they adhere to U.S. governmental positions in such meetings. That is a broad separation.

Mr. VIVIAN. I am sure you are familiar with COSPAR?

Mr. POLLACK. Yes.

Mr. VIVIAN. I understand there is both an American and a Russian delegate to that organization. I gather they are there principally in the role of representatives of their respective governments rather than scientific representatives.

Mr. POLLACK. I don't think so. May I just turn to Mr. Packard for a bit of advice?

Mr. PACKARD. No; that is not true. I am Robert Packard, head of the Outer Space Affairs. COSPAR is a nongovernmental international scientific committee. Its bureau consists of five, I believe, scientists. There is nothing in its bylaws or charter which provides that two of these be one an American or one a Soviet. By practice in logrolling within the organization this has been the case, and the American and Soviet members of their bureau or executive committee have served as the two vice presidents of the organization.

Mr. VIVIAN. This is not by requirement but it does happen.

Mr. PACKARD. Really by the practicalities of the fact that the two countries that can make contributions in this are the United States and the U.S.S.R.

Mr. VIVIAN. Are there any other American members who are active in COSPAR?

Mr. PACKARD. At the last meeting of COSPAR there were something on the order of 107 American participants.

Mr. VIVIAN. What happens if they disagree with the nominal position taken by the vice chairman?

Mr. PACKARD. They are free in COSPAR to express their views on the scientific problems and in the corridors to express their views on anything else they see fit. The decisions of COSPAR as an organization are made by its executive committee and by its representatives voting in plenary session. The composition of COSPAR is the national academies of the countries who participate, plus some representatives from the international scientific unions. The American participant in COSPAR has one vote.

Mr. VIVIAN. Is it the vice chairman of the executive committee who is the decisionmaking agency, and the assembly—I am sorry, I don't remember the label——

Mr. PACKARD. A plenary session of COSPAR.

Mr. VIVIAN. What happens if the executive committee and the plenary session disagree?

Mr. PACKARD. The executive committee makes recommendations to the plenary session and votes are taken in the plenary session.

Mr. VIVIAN. What happens if the executive committee votes one way and the plenary session votes the other?

Mr. PACKARD. There is only one vote in the plenary session, and he is the same man. He is the representative of the U.S. National Academy of Sciences, which is the American institutional member of COSPAR.

Mr. VIVIAN. I think you have answered the question which I have. I would like to go on to the matter of cultural exchanges. What funds are provided directly from the State Department for cultural exchange in the scientific areas?

Mr. POLLACK. I will have to supply an accurate answer for you on that for the record.

Mr. VIVIAN. Is it in tens of thousands of dollars or is it in millions?

Mr. POLLACK. It is not in millions.

(The information requested is as follows:)

DEPARTMENT OF STATE, BUREAU OF EDUCATIONAL AND CULTURAL AFFAIRS

TABLE I.—*Grantees in physical and natural science fields* [1] *(July 1963 to June 1964)*

Area	Students		Teachers		Lecturers		Research scholars		Specialists		Leaders, foreign	Educational travel, foreign	Total	
	United States	Foreign	United States	Foreign	United States	Foreign	United States	Foreign	United States	Foreign			United States	Foreign
Africa		192	4		9				1	4	5	4	14	205
Other American republics	2	105	1	11	35	1	3	25	3	7	8	114	44	271
Europe	67	339	12	21	37	30	41	229	6	6	18		163	643
Far East	10	141	2	5	15	8	14	88	3	7	7		44	256
Near East		254	12	19	36	6	12	42	3	11	13		63	345
Total	79	1,031	31	56	132	45	70	384	16	35	51	118	328	1,720

[1] This table reflects the numbers of persons on new grants during 1963–64 as well as those on grants extended from a previous year, for which additional funds were obligated.

Under the Department's program, the cost of grants awarded to persons in the fields of natural and physical sciences for the 1963–64 year amounted to $5,915,000. Included in this amount was the cost of the grants to teachers and lecturers in science fields in the amount of $1,388,000. Excluded from the total cost was the financial support involved in postponed travel for 1,173 grantees in science fields who were permitted to remain in the United States to complete their work and were allowed to use funds from previous allotments for their return travel.

Mr. VIVIAN. You indicated that a certain amount of funds were provided to the National Academy of Sciences for its activities overseas. Does this funnel through NSF?

Mr. POLLACK. Well, the role played by the National Academy of Sciences in the exchange of programs with the Soviet Union and certain of the bloc countries are obtained by them on grant from the National Science Foundation which in turn is making its investment on the basis of advice obtained from the Department of State that we think would be in the national interest for such a program to be conducted.

Mr. VIVIAN. Has the National Academy of Sciences ever asked for more funds than were granted?

Mr. POLLACK. I just don't know, sir.

Mr. DADDARIO. Will you provide that for the record?

(The information requested is as follows:)

FUNDING OF EXCHANGES OF SCIENTISTS ARRANGED BY THE NATIONAL ACADEMY OF SCIENCES AND ACADEMIES OF SCIENCE OF THE U.S.S.R. AND OTHER COUNTRIES OF EASTERN EUROPE

During the last 3 months of 1957 the Department of State conducted negotiations with representatives of the Soviet Government headed by Soviet Ambassador Georgi N. Zaroubin to achieve the first U.S.–U.S.S.R. intergovernmental agreement on cultural, educational, and technical exchanges between the two countries. In the course of the negotiations, the principal U.S. negotiator, Ambassador William S. B. Lacy, informed the President of the National Academy of Sciences (NAS), Dr. Detlev W. Bronk, that the Soviet negotiators had proposed inclusion of a provision for exchanges of scientists to be worked out by the NAS and the Academy of Sciences of the U.S.S.R., and he asked for Dr. Bronk's comments and guidance concerning the proposal. In response to the Government's desire to include provision for interacademy exchanges in the intergovernmental agreement on exchanges, the NAS agreed to cooperate and such a provision therefore appeared in section IX of the so-called Lacy-Zaroubin agreement of January 27, 1958. It may be noted that this brought into being an exchange arrangement between the two academies of a sort previously suggested to the NAS by the Soviet Academy in 1955. The earlier proposal did not develop significantly, in part at least because of the Hungarian revolution of 1956.

The negotiation of an interacademy exchange agreement as envisaged in section IX of the 1958 intergovernmental agreement was delayed at first because NAS President Bronk was unable to travel to Moscow until October 1958 because of his health. In October, Dr. Bronk was able to go and, as a result of his discussions with Soviet Academy President A. N. Nesmeyanov, returned with a draft exchange agreement for consideration by NAS governing officials. Negotiation of the agreement continued slowly by mail through the following winter and spring, and the text was finally signed as of July 9, 1959.

Prior to Dr. Bronk's departure for the U.S.S.R., the Acting Secretary of State, Mr. Christian A. Herter, wrote to him on October 4, 1958:

"These exchanges are of considerable importance and interest to the United States. I want to assure you that the Department of State strongly supports whatever impetus you can give to establishing a sound program that will involve a significant number of scientific exchanges. We shall be glad to assist you in any way possible to expedite your conference."

Dr. Bronk was accompanied on his mission by Dr. Wallace Brode, Science Adviser to the Secretary of State.

FUNDING OF THE U.S.-U.S.S.R. INTERAGENCY EXCHANGES

It had been understood between the National Academy of Sciences and the Department of State that provision for an interacademy agreement within the intergovernmental exchanges agreement implied no financial support from the Department. Thus, the National Academy of Sciences turned to the National Science Foundation (NSF) for funding. The National Academy of Sciences submitted its first request for support of the program to the National Academy of

Sciences on April 6, 1959, by which time the terms of the Bronk-Nesmeyanov exchange agreement were evident. That request was based on estimated maximum expenditures of $467,000 for completion of all exchange activities in the 2-year period of the agreement. In response, the National Science Foundation, on September 2, 1959, granted the National Academy of Sciences $235,000 for the conduct of the exchange program for a period of approximately 1 year, effective July 9, 1959. Because a considerable leadtime was required before individual visits could actually commence, the goal of accomplishing half the activities provided in the interacademy agreement of 1959 was not reached at the end of the first year, July 9, 1960. Therefore, the National Academy of Sciences later proposed to the Soviet Academy that the agreement be carried beyond the original 2-year term and continued through calendar year 1961. In July 1960 the period of the National Academy of Sciences grant was also extended for an additional year, and it was subsequently extended again for 1 year more, to July 1962.

The extensions of the grant which had been based on estimated needs for the first year only reflect not only the delay in the beginning of travel of exchange scientists and attendant expenses but also the fact that a number of activities for which a need for funds was anticipated never materialized. Thus, the original grant of $235,000 maintained the exchange program for more than 2 years.

A considerably enlarged continuation of the interacademy program resulted from the negotiation in early 1962 of a new 2-year interacademy exchange agreement as part of a new 2-year intergovernmental exchanges agreement. Whereas the first interacademy agreement had been worked out, independent of the period of validity of the intergovernmental exchanges agreement, as it turned out, its conclusion coincided with that of the intergovernmental agreement for 1960–61. It was signed on the same date also, March 8, 1962, and it appeared as annex No. 1 of the intergovernmental agreement.

Meanwhile, in support of exchanges still in effect under the 1959 agreement, the National Academy of Sciences, in April 1962, requested an additional $45,675 from the National Science Foundation. That amount was granted for a period ending August 31, 1962.

In order to support activities under the second interacademy agreement of March 1962, the National Academy of Sciences requested of the National Science Foundation $260,110 for the first of its 2 years. The National Science Foundation, on November 9, 1962, granted that amount to the National Academy of Sciences for a period of approximately 1 year ending in September 1963.

In August 1963 the National Academy of Sciences submitted to the National Science Foundation a request for additional support in the amount of $282,676 for operation of the interacademy exchange program from September 1963 through August 1964. The budget estimate underlying this request was based on the assumption that most of the visits provided in the exchange agreement for 1962–63 would be made, and the National Academy of Sciences had obtained agreement from the Soviet Academy that individual visits within that agreement might be made through academic year 1963–64, that is, through June 1964. Toward the end of 1963, however, it became clear that the full number of visits provided in the agreement would not be made. Accordingly, in December 1963 the National Academy of Sciences revised its request of previous August downward from $282,676 to $218,662 for the same period, September 1963 through August 1964. The request was granted and the task order was extended through November 30, 1964.

In February 1964 the National Academy of Sciences and Soviet academies concluded a third exchange agreement, once again a part of a new intergovernmental exchanges agreement for 1964–65. To carry out the activities for the first year of the new agreement and to continue activities pending under the 1962 agreement, the National Academy of Science asked the National Science Foundation for $230,000 for the 15-month period from June 1, 1964, through August 31, 1965. That amount was granted in December for a period ending August 31, 1965.

In July 1965 the National Academy of Science asked the National Science Foundation for continued support in the amount of $272,375 for the period from September 1, 1965, through August 31, 1966. That request is now pending.

FUNDING OF EXCHANGES WITH ACADEMIES OF EASTERN EUROPE

In response to a recommendation of the National Academy of Science Advisory Committee on U.S.S.R. and Eastern Europe, the governing officials of the National Academy of Science decided that the National Academy of Science might properly inaugurate modest exchange programs with the academies of sciences of Poland, Yugoslavia, Rumania, Hungary, and Czechoslovakia. As a first step it was considered desirable for small delegations of senior scientists from one country to visit the other in order to survey current research, identify laboratories in which one's own scientists might profitably be placed for research, identify scientists of the other country who might be invited to ones' own country, and to discuss with officials of the other academy the conditions under which bilateral exchange arrangements might be worked out by the National Academy of Science and the other academy.

For initial delegation visits to and from Poland and Yugoslavia, the National Academy of Science sought support from the National Science Foundation in December 1963 in the amount of $15,960. The request was supported by Dr. R. Rollefson, Director of International Scientific Affairs, Department of State, who wrote, as follows, to Dr. Leland J. Haworth, Director of the National Science Foundation, on January 22, 1964:

"The Department of State supports the project as proposed by the National Academy of Sciences as being in the foreign policy interests of the United States and would, therefore, appreciate your giving favorable consideration * * * to supporting the request of the National Academy of Sciences * * *."

In February 1964 the National Science Foundation acceded to the National Academy of Science's request for $15,960 for a period from February 1, 1964, through August 31, 1964. This task order was subsequently extended through August 31, 1965.

In April 1965, in anticipation of initial delegation visits between the National Academy of Sciences and the academies of sciences of Rumania, Hungary, and Czechoslovakia, the National Academy of Sciences requested an additional $15,000 from the National Science Foundation. In June 1965 the National Science Foundation amended the earlier task order to reflect the additional sum and also to extend the entire task order through August 31, 1966.

In view of the concurrence of the Polish Academy of Sciences and the Yugoslav Council of the Academies in similar memorandums of understanding on exchanges and the anticipated commencement of modest exchange programs with them during the winter of 1965–66, the National Academy of Sciences is in the process of submitting to the National Science Foundation a request for additional support in the amount of $75,000 for these exchanges during the current fiscal year.

Mr. Vivian. I would appreciate its request and the history starting with the National Academy of Sciences initial request.

Are you aware that National Science Foundation or the National Academy asked for funds for cultural exchange programs considerably above the existing level?

Mr. Pollack. I am not aware of that. I don't believe that it has happened.

Mr. Vivian. Is there any provision made by the State Department for extensive international exchange of teachers of science?

Mr. Pollack. There is a program carried on by the Bureau of Cultural Affairs for the exchange of teachers, some of whom are in the scientific field, but again, to give you a precise figure how many of these are in the scientific field, I would have to go back and obtain the record on that.

Mr. Vivian. Are there any major programs for exchange of teachers irrespective of whether they are in the scientific field or not?

Mr. POLLACK. I think I would call them major, yes. Money is being expended on this purpose by the Office of Education and by the Department of State.

Mr. VIVIAN. I would appreciate a summary of those. I would appreciate having the scientific exchange delineated but not subtracted from the total.

Mr. POLLACK. Right.

(The information requested is as follows:)

DEPARTMENT OF STATE, BUREAU OF EDUCATIONAL AND CULTURAL AFFAIRS

TABLE II.—*Grants for secondary and university teaching (1963–64)*

Field of specialization	Teachers				University lecturers				Total	
	United States		Foreign		United States		Foreign		United States	Foreign
	New	Extension	New	Extension	New	Extension	New	Extension		
Physical and natural sciences	30	1	54	2	125	7	44	10	163	110
Social sciences	108	3	95	....	175	13	42	5	299	142
Humanities	243	21	76	26	110	10	95	22	384	219
Education	60	2	621	10	39	1	2	....	102	633
Total	441	27	846	38	449	31	183	37	948	1,104

NOTE.—This table shows only those grants awarded under the educational exchange program of the Department of State for secondary and university teaching. Other grants on this program are made to American and foreign college students, research scholars, specialists, and leaders. The Department also gives some financial support to organizations such as the American Field Service and the National Catholic Welfare Conference to assist their programs with teenage students from abroad.

These statistics are compiled on the basis of new grants (those which were awarded for the year 1963–64) and extension grants (those which were extended from a previous year). Included in the count for foreign extension university lecturers in the physical and natural sciences are 9 grants involving no additional expenditure.

PRINCIPAL EXCHANGE PROGRAMS CONDUCTED BY U.S. GOVERNMENT AGENCIES [1]

1. Department of State—Bureau of Educational and Cultural Affairs

Under the Mutual Educational and Cultural Exchange Act of 1961 (Public Law 87–256), known as the Fulbright-Hays Act, the Bureau administers an exchange program to increase mutual understanding.

(*a*) Makes grants annually to more than 2,300 U.S. citizens to go abroad and over 5,600 foreign nationals to come to the United States. Since adoption of the original Fulbright Act in 1946, over 26,000 Americans and more than 64,000 foreign nationals have participated in the program. Grants are made for university lecturing, advanced research, graduate study, teaching in elementary and secondary schools, practical experience in technical and specialized fields, and consultation and observation.

(*b*) Also has responsibility for a wide range of related activities, such as overseas tours by performing artists, music and drama groups, and athletes; bringing foreign leaders to the United States and sending out doctors, writers, coaches and other American "specialists."

2. Agency for International Development (AID)

(*a*) Participant training program: Brings approximately 6,000 foreign nationals to the United States each year for widely varying periods of time, for project-oriented training in agriculture, education, industry, labor, transportation, public administration, public health, etc.

(*b*) University contract programs: Sends U.S. university personnel overseas under contract arrangements with foreign governments and institutions to help establish and strengthen faculties, improve curricula, etc.; brings foreign faculty and students for training at U.S. universities.

[1] See "Explanatory note."

3. Department of Defense

(*a*) Military assistance program: brings approximately 18,000 foreign military personnel to the United States for training periods ranging from 2 weeks to 3 years; sends teams of U.S. training personnel abroad.

(*b*) Brings foreign Navy and Marine officers to the United States and sends U.S. officers to other countries for the purpose of standardization of naval operations.

(*c*) Ryukyus exchange program: Brings leaders and university students to the United States for observation and study; sends U.S. professors to assist in the development of the University of the Ryukyus.

4. Department of Health, Education, and Welfare

(*a*) National Institutes of Health:

(1) Brings young scientists and research trainees for training and senior scientists for collaboration with NIH personnel.

(2) Gives fellowships to American scientists for study and research abroad.

(*b*) U.S. Office of Education:

(1) Language development program brings foreign professors to teach at language institutes under the National Defense Education Act (NDEA).

(2) Language development program sponsors institutes for elementary- and secondary-school language teachers under the NDEA.

(3) Makes grants to advanced U.S. graduate students, preparing for college training, to study overseas under the Fulbright-Hays Act.

(4) Sponsors summer seminars for professional development in language and area studies, principally for secondary-school teachers, under the Fulbright-Hays Act.

5. National Aeronautics and Space Administration (NASA)

(*a*) Brings senior foreign scientists for advanced research at NASA centers.

(*b*) International University Fellowship Program brings foreign students for study and research in space science at U.S. universities.

(*c*) Brings foreign technicans for training at NASA centers.

6. National Science Foundation (NSF)

(*a*) Inter-American Exchange of Scientists Program: This program, administered by the Organization of American States (OAS) and partially financed by NSF, provides for the exchange of scientists between the United States and other OAS member countries.

(*b*) Exchanges with the U.S.S.R.: An NSF-supported program, administered by the National Academy of Sciences, provides for an exchange of scientists with the Soviet Academy of Sciences.

(*c*) Programs for American scientists: Grants for international travel for meetings and for exchange of information on scientific research; fellowships for study and research abroad.

(*d*) Programs for foreign scientists:

(1) Senior foreign scientist fellowship program brings senior scientists for visits to U.S. universities.

(2) Visiting scientists, brought to the United States by American scientific societies with NSF support for lectures, seminars, and consultations.

(3) Foreign scientists are brought to lecture in NSF summer institutes for U.S. secondary school and college science teachers.

7. Peace Corps

Sends qualified American men and women to interested countries to help meet their need for trained manpower, promotes a better understanding of the American people in those countries, and promotes a better understanding of other people on the part of the American people.

EXPLANATORY NOTE

The above listing includes those agencies conducting the principal programs under which Americans go abroad and foreign nationals come to the United States for educational, scientific, and cultural purposes. Many other agencies are involved in providing a variety of services for foreign visitors under these programs and in supplying personnel, principally to AID, for training programs abroad.

Mr. VIVIAN. With regard to the exchange, would it cover one teacher in a thousand throughout the world each year, or some larger or smaller figure?

Mr. POLLACK. I would think a smaller figure than that.

Mr. VIVIAN. In other words, 1 in 10,000, perhaps?

Mr. POLLACK. Possibly.

Mr. VIVIAN. Has any consideration been given to increasing that number by a very large amount?

Mr. POLLACK. I know that this prospect has been considered, but I have not been party to that consideration and cannot tell you how far it has gone.

Mr. VIVIAN. Can you tell me approximately who would have this information?

Mr. POLLACK. I would turn myself to the Bureau of Cultural Affairs, for this information, of the State Department.

Mr. VIVIAN. Not the Office of Education?

Mr. POLLACK. No. I may end up there before I could complete my statement.

Mr. VIVIAN. I am now in the course of trying to prepare a bill for submission to the Congress which would enormously increase the amount of cultural exchange of teachers in the United States, and I am having enormous difficulty finding out who has responsibility for this in the Government.

Mr. POLLACK. It was part of the origin of this piece of legislation which I knew had been under consideration, but I didn't know whether it had reached the state of legislative proposal.

Mr. VIVIAN. I would appreciate it if you could identify the participants so I can talk about them. I have no further questions.

Mr. ROUSH. How many countries maintain scientific attachés in this country?

Mr. POLLACK. I think our last count numbered about 15.

Mr. ROUSH. Are these for the most part the same countries in which we maintain a scientific attaché?

Mr. POLLACK. There is a fairly high correlation, but there are a few countries that maintain attachés here where we do not participate.

Mr. ROUSH. If a Government agency sends a delegation or a representative to an international meeting, does the State Department control the official statements of policy of those particular agencies in any way?

Mr. POLLACK. Yes, sir.

Mr. ROUSH. There is a requirement that they do coordinate with the State Department?

Mr. POLLACK. Yes, sir; there is, sir.

Mr. ROUSH. Even if another agency is sponsoring the program?

Mr. POLLACK. Yes.

Mr. ROUSH. I have no other questions.

Mr. DADDARIO. Mr. Pollack, what are the scientific attaché's capabilities to attend meetings which he believes are important, and what funds are provided to him? How restricted is he by the control of the embassy at which he happens to be stationed?

Mr. POLLACK. Mr. Chairman, I made a canvas of the attachés on that very point about 3 months ago, and I was myself surprised by the fact that the picture was as good as it apparently is. We have 16

countries in which we have attaché posts, and my recollection is that in about 13 of them our attachés had about as much money for travel purposes and attendance at meetings as they were able to devote their time to, and they were quite satisfied with their capacity to move about. In three of our posts the problem is still existent, and we are taking steps to see if we can improve that situation.

Mr. DADDARIO. Could you provide for the record more information on that?

Mr. POLLACK. Yes.

(The information requested is as follows:)

ATTENDANCE OF SCIENTIFIC ATTACHÉS AT SCIENTIFIC MEETINGS

The scientific attachés are authorized to attend any meetings which they believe are important and are related to their responsibilities or are within their general area of scientific competence. Funds for travel to meetings within the country of assignment are provided and controlled by the embassy. To the best of our knowledge none of the attachés have been denied the opportunity to attend such meetings.

For travel to meetings outside the country of assignment funds are allotted specifically for such purposes and administered by the embassy. During fiscal year 1964 61 trips were authorized for attachés to attend either scientific meetings or to engage in orientation travel outside their country of assignment.

Mr. DADDARIO. You mentioned NSF's role as far as its international participation is concerned and you envision for it a greater field of activity. Could you go into that a little further?

Mr. POLLACK. Yes; I would be glad to. I should make clear that I speak of an agency such as the National Science Foundation. This thought has not been pursued far enough in the executive branch for that to yet be our chosen instrument. But the budgets of the various departments and agencies that carry scientific and technical programs are generally built around the mission of the agency, the so-called domestic mission proper. They are in the process of putting together an annual or a projected plan over several years do so in terms of priorities that are developed essentially from their perspective of the domestic considerations which determine their pursuit of this course of action as opposed to that course of action. Secondly, each of these departments in town is by definition concerned with its own responsibilities. Essentially, it protects its own budget, it protects its own piece of territory so to speak, and there is I think a mutual diffidence about not getting into the other fellow's territory. We have many budgetary and legislative mechanisms at work here to keep the relative jurisdictions of the departments separate and distinct from each other.

Now, there are opportunities and there are requirements, and I am suggesting I think there are going to be more of them in the future than there have been in the past, where it will be desirable for the United States to pursue a scientific relationship, be it cooperation or what have you, that is neither related, per se, in the first instance to the priorities that have been established by the domestic agencies for the pursuit of their domestic purposes or that do not fit the jurisdictional territories and boundaries that have been established by the nature of the U.S. Government's organization. Now, in these cases it becomes a rather cumbersome and excessively complicated problem to organize the U.S. Government to respond to this kind of an oppor-

tunity. In the first instance, agencies don't feel, and it is understandable why they would hold this point of view, that they are authorized to spend funds available to them for this kind of activity. Second, it hadn't been anticipated in the development of their budgetary program. They have their own congressional committee to deal with, their own constituencies in the United States to take into account.

Second, if it involves more than one agency, it immediately gives rise to coordination and division of responsibility, and when you get to three or four you have all the complications and problems of committee management. I am suggesting in the statement that it would be desirable to have a way to deal with these opportunities that is more immediate and more direct and more responsive which would be to provide broad authority to the executive branch to engage in scientific endeavors for the benefit of science per se, for the benefit of the international status of science. I am not suggesting, necessarily, that were this responsibility to end up with an agency such as the National Science Foundation that they would undertake these programs and carry them on from that point forward. They might undertake to provide the seed money required to get the thing started until the normal budget process could relate this back again to the domestic agency most appropriate for the function. They might simply provide the funds to a domestic agency which already has the capability and the staff appropriate to the subject. But it would provide a way of dealing with two aspects of this problem: one, the lack of distinct authority, and second, to the question of providing multiagency participation when necessary.

I noticed this morning that Governor Harriman apparently had a talk with Vice Premier Rudnev, and he talked about cooperation in the scientific and technological fields, and Mr. Gross, who wrote this article, made the point that if the present Harriman contacts can open an effective dialog on matters unrelated to Vietnam it would be a significant gain. I would subscribe, I think, to that point of view. I do not know, at this point, what might come out of this kind of proposal, but it is entirely possible that the scientific cooperation might involve an activity that does not neatly tie into a single department or agency of the U.S. Government, and it might call for a participation or collaboration in an effort which, at this point in time, under priorities established by the domestic departments, they were planning to approach, a year or two hence. The international purposes that might be served by this collaboration, if put into the balance, might call for this priority to be moved up and this problem to be approached at this point in time. This is the essence of my point.

Mr. DADDARIO. I hope we will be able to send additional questions to you, Mr. Pollack.[1] We have a rollcall vote; otherwise, we would continue. I would like to commend you and your staff for coming here this morning to be with us.

This committee will adjourn until tomorrow morning at the same place at 10 o'clock.

(Whereupon, at 12:22 p.m., the subcommittee adjourned to reconvene at 10 a.m., Wednesday, July 21, 1965.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

WEDNESDAY, JULY 21, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. This meeting will come to order.

Our first witness this morning is the very distinguished president of the University of Notre Dame, Father Theodore M. Hesburgh. We are pleased to have you here, Father Hesburgh, and especially so because of the fact that you have served for many years as a member of the National Science Board. This is particularly important as we review the activities of the National Science Foundation. We are anxious to hear from you.

Mr. Roush. Mr. Chairman, coming from Indiana, I especially want to add a word of welcome to Father Hesburgh, and to tell the other members of the committee that Notre Dame has achieved new stature under the leadership of this distinguished man. I am especially proud that he is here testifying before our committee.

STATEMENT OF REV. THEODORE M. HESBURGH, C.S.C., PRESIDENT, UNIVERSITY OF NOTRE DAME

Father Hesburgh. Thank you, Mr. Roush, Mr. Daddario, gentlemen.

I appreciate very much the opportunity to take part in these hearings which I judge to be most important. As you know, for the past 11 years I have had the privilege of serving as a member of the National Science Board, and also, for the past 13 years I have been president of the University of Notre Dame. I am sure it must be evident to you that because of each of these two associations, I have had a deep and continuing interest in the activities of the National Science Foundation. But over and above these, as an educator and as a citizen of this country, I have observed the growth and development of the Foundation with great satisfaction—for I believe that it has exerted, and will continue to exert, an important and beneficial influence on our science and technology and on the education of future scientists, and, through these, on the welfare of our Nation as a whole.

I believe that all of us have reason to be grateful to those who conceived the concept of a National Science Foundation, to those who en-

acted the wise legislation which created it and to those who have sympathetically supported it during these first 15 years of its life. These have included, of course, not only Dr. Vannevar Bush but also four Presidents of the United States and a great many Members of the Congress.

As you know, the Foundation is comprised of a National Science Board of 24 members, appointed by the President, and the Director who, ex officio, is also a full member of the Board.

The National Science Foundation Act assigns policy determination to the Board. The Director, appointed by and responsible to the President, is the chief executive officer of the Foundation as well as a member of the Board. This is a unique organizational structure among Federal agencies and seemingly includes a division of responsibility which might, to some, appear to be theoretically unwise. However, I can bear witness to the splendid cooperation which has existed between the Board and the Directors—first Dr. Alan Waterman and, during the past 2 years, his capable successor, Dr. Leland J. Haworth. I can testify, from 11 years of personal experience, that the Board and the Director, working cooperatively and harmoniously toward common goals, have indeed been the Foundation as the act prescribes they shall be.

The original version of the NSF Act stated that no final actions relating to the award of grants or fellowships might be taken unless, in each case, the Board had reviewed and approved each such action. However, the act as amended in 1959 permits the Board to delegate to the Director this authority of review and approval.

During the early years of the Foundation, it became obvious that the Board should not concern itself with all of the many individual actions which are necessary. Accordingly, it has delegated such authority to the Director and limits its own review and approval activity to those matters that involve special policy considerations or very large sums of money. The Director and his staff, on the other hand, have always taken pains to keep the Board well informed in detail of all the actions taken under the delegated authority.

The Board, on its part, has concerned itself increasingly with more general policy matters relating to strengthening of the scientific research and education of the country. To this end, about a year ago we revised our committee structure to permit more effective policy consideration. We now have three principal standing committees in addition to the executive committee.

One of these is charged with consideration of policy matters relating to substantive, programmatic areas of science and education. Another is concerned with policy problems which arise from administrative considerations, particularly those connected with Foundation-university relationships. The third committee deals with long-range program and policy questions pertaining to the role of the Foundation, in the context of the total Federal and national picture, in research and education in the sciences.

Although this committee structure is relatively new, it is already showing its usefulness. The committees meet frequently and are able to give deep and careful consideration to specific policy questions. Their findings and conclusions are reported to the Board which then has a basis for taking well considered action. With the Board

freed of much of the detail work and with a mechanism for policy consideration and formulation operating so well, I believe the Board will be an even more effective instrument for development of measures to strengthen our country's science enterprise.

I should like, Mr. Chairman, to turn now to some of the substantive aspects of the Foundation's operations. I shall not devote much time to discussion of the support which the Foundation provides for basic research through its project system, its facilities grants, institutional grants, the national centers, and so on. I believe there is common agreement that this support has had an enormous beneficial influence on the growth and development of our national science enterprise. The Foundation's influence has been most pronounced, of course, on our basic research effort which is to be found largely in our universities. The very act of creating a national agency devoted to basic research has lent a new prestige to this field of activity. Its nourishment though generous—though still inadequate—appropriations which were wisely administered permitted marked expansion and increased productivity. It is in considerable measure for these reasons that our basic research enterprise today is the envy of all the world. It is factors such as these which are responsible for our recent production of such a large proportion of Nobel Prize winners. And, to a considerable degree, these are the reasons behind the current strength and vigor and high level of excellence of our entire national scientific enterprise. Obviously we can all derive great satisfaction from this situation. I can assure you, Mr. Chairman, that I do.

I believe we all agree on these points and there is no need for me to belabor them. However, I should like to dwell for a moment on the Foundation's support of social science research.

One of my early assignments as a member of the National Science Board was to chair a Board committee on the social sciences. This, coupled with my own background training and interests, has led me to follow these activities very closely and with considerable attention.

I single out the social science activities for comment not only because of the high regard I have for the Foundation's role in this field, but also because it has come to my attention that during previous sessions of these hearings some of you have evidenced considerable interest in this phase of its activities.

Although the act does not specifically enumerate the social sciences as it does the natural sciences, it does include authority to award grants and contracts for basic research, as well as fellowships, in what are referred to as "other sciences." The report on the bill which became the National Science Foundation Act, and its legislative history, clearly indicate that it was intended that the Foundation should explore the needs of the social sciences and take appropriate action with respect to them.

In 1953, the Foundation began to study what its proper role might be with respect to the social sciences. A limited research support program, begun in 1954, has been gradually and cautiously extended. In 1960 the Board approved the establishment of a Division of Social Sciences. This is coordinate with the other research divisions, and now supports research in anthropology, economics, psychology, sociology, political science, geography, and linguistics. Current obligations for research grants in the social sciences are at the level of about $10 million per year.

As research support in the social science fields has grown, so have the social science aspects of the Foundation's education, training, and other science support efforts. The programs which provide fellowships for graduate students, and those which support curriculum studies, science information activities, construction of laboratory buildings and facilities, science development awards—all are open to the social sciences just as they are to the natural sciences.

This experience has demonstrated that the same agency can indeed support the social and the natural sciences. Although the problems and methodologies differ from field to field, the objectives and intentions are similar. In all these fields, fundamental research is principally university-based and the standards and criteria are very much alike.

The same decade that has seen the Foundation expand in this area has seen the Federal Government as a whole become more involved in the areas of social science concern. We are all familiar with these. The problems of arms reduction, of population increase and mobility, of urbanization and of urban renewal, of equal rights and equal opportunity, of poverty and of peace—all of these and many other social problems are major concerns of our Government. Many new programs directed toward amelioration of these pressing social needs have been developed.

The Foundation's support of basic research in the social sciences has helped to serve as a valued adjunct to these efforts. It may be difficult for some to see the immediate connection between an experimental study of human communication and increasing the possibility of peace in the world, or between an econometric model of the economy and learning how to prevent a recession or inflation.

However, the potential is there and basic research in these fields, as in others, provides understanding which, in the long run, will surely have a great impact—and particularly so in proportion to its initial cost.

In short, I believe it important that the Foundation has developed its social science support programs and that these operate in the same way and by the same principles and criteria as do the natural science programs.

It is important that support of fundamental academic research in the sciences has been provided on a broad, nondiscriminatory base and that this has helped to give recognition and status to the social sciences as legitimate areas of research. The development of such areas into full-fledged fields of scientific exploration is a most significant contribution, and in my belief, should be continued and expanded.

I should like to mention several of the Foundation's educational activities which, in my view, are of very great significance to our national interest. One of these is its program of fellowships, supplemented more recently by a traineeship program. These have proven to be highly effective means of insuring the future scientific strength of the Nation by providing opportunity for our young people of highest ability to continue advanced training in science, mathematics, and engineering. I want to stress particularly those programs which are directed toward graduate students—the young people who have completed their bachelors work and have turned to pursuit of an advanced degree, the masters or the Ph. D. The Foundation's graduate fellow-

ship is a form of grant to such an individual, selected in a national competition on the basis of ability and promise.

The graduate fellowship program permits the student to pursue that field of science which interests him most. It is based on the well founded premise that students at this educational level know quite accurately in what subject matter areas they wish to build their careers.

Accordingly, fellowships are awarded—after national competition—on the basis of merit and ability without assignment of quotas by field or discipline. Only in cases of substantially equal merit do considerations such as discipline or geographical origin enter the picture.

In talking about the graduate fellowship program, Mr. Chairman, I have referred to merit, ability, and promise as criteria for selection of fellowship recipients. Speaking as a university president, I can verify that the Foundation's fellowship awards have been made to our most able graduates. And this is as it should be. Those who framed the National Science Foundation Act directed that fellowship recipients should be selected on the basis of ability. I believe this was a wise decision because if we are to provide the Nation with the best possible scientific talent, it is mandatory that we assure our most able and best trained young people the opportunity to work toward this end.

The act also directs that the fellowship recipients shall be permitted to attend the institutions of their choice. As a consequence, they tend to select those institutions which are most outstanding in the quality of their offerings for training in the sciences. This is understandable, and is in the best interests of the Nation. These high-ability young people deserve the best possible opportunity to complete their development into mature scientists. However, it is clear that the resultant concentration of graduate students at a few institutions does not contribute directly to the development of graduate education at other institutions. Recognizing this situation as a further responsibility, the Foundation has sought means to extend the geographical and institutional distribution of high-ability graduate students. A principal effort in this direction has been the introduction of the traineeship program which differs from the graduate fellowship program in several ways. One is that the university, rather than the Foundation, selects the award recipients. Also, in the traineeship program, the Foundation decides, within limits, on the distribution of awards among the various fields of science. Both these effects are achieved by permitting the university to apply for the number of traineeships it believes it needs for each of the several eligible fields of science. The Foundation then evaluates these requests, taking into account the resources for graduate training of each such department as well as the capacity of the department to increase or accelerate its output of graduate students. On the basis of such evaluation, specific numbers of traineeships are awarded to each of the approved departments. Thereafter, the department and the institution deal directly with the student applicant and the selection remains a local one.

The traineeship program is much newer than the fellowship program and we have not had as much experience with it. However, I am confident that I reflect the belief of my fellow Board members when I say that we heartily endorse this second, but by no means inferior,

mechanism for assisting in graduate science education. Through this means the Foundation is able not only to broaden its geographical and institutional distribution of funds and to assist in the development of graduate education at a larger number of institutions but also it is enabled to respond to immediate and short-run demands for additional trained manpower in particular scientific fields.

In speaking of the fellowship program, Mr. Chairman, I have concentrated on the education of young people seeking training toward the masters and Ph. D. degrees. I have not touched on the several programs for postdoctoral scholars and for summer study or research of teaching assistants. These, too, are important and worthy efforts. Of particular significance, I believe, is the program of science faculty fellowships which enables undergraduate teachers at the smaller institutions to make progress toward their own advanced study or to obtain much needed intermittent refreshment and updating on scientific subject matter.

These fellowships permit more mature scholars to intermingle study with teaching and research. They are particularly profitable in that they assist in a material way to improve the quality of science teaching at our smaller institutions of higher education, especially those which are less heavily involved in research.

Mr. DADDARIO. Father Hesburgh, you stress the importance of intermingling study with teaching and research. We have had during the course of these hearings some concern about the fellowship recipients not becoming sufficiently involved in teaching. There has been some attempt made to develop this further and there has been, for example, the authority allowed to the universities to grant them up to a certain amount of money as an inducement to teach.

What has been your experience with that, and do you think the situation might be improved?

Father HESBURGH. My experience is a personal one at our own university, but what we have found as a general rule is that it is not good to have first-year graduate students teaching. In other words, there is a break between high school and college, there is a break between college and graduate school, and as general rule of thumb we greatly discourage and rarely permit first-year graduate students to teach. As they get on to their second and third year, we think a little teaching is a good thing. First of all it gives them a little of the drama of teaching and induces them to get interested in the teaching profession, and, secondly, they are more qualified to teach at that time. But here, too, there is a danger, if you get them too involved in teaching, then they will never get on to the finishing of their research and their dissertation work. I think one of the greatest needs in graduate students in all departments today is to get students through. Some students become perpetual students, and there are times when the institution somewhat fosters this by using them too much for teaching when they should be studying and doing research. So our own particular experience is that we greatly discourage any teaching in the first-year graduate studies, we permit it only to a lesser degree in the second and third year, and try to stop it during the dissertation year so they get finished and get out and get to work in teaching and research.

Mr. DADDARIO. Do you find there is a desire within this group to teach or is it something that needs to be given some impetus?

Father HESBURGH. I think it needs a little encouragement. I would be for all graduate students teaching at some time in their career, because there is only one way you get to love teaching and that is by teaching. I believe there is a great deal of glamor surrounding research nowadays, which is understandable, the excitement of finding new knowledge, of participating in the joy of discovery, but at the same time there is also a great joy in bringing minds to life, and this is the joy of teaching. I would hope that a student in all of our graduate schools would get some experience with both of these experiences because they are both important in the total maturing of a graduate student.

Mr. DADDARIO. How has the formula worked out at Notre Dame? Have you had sufficient experience so that you can trace it?

Father HESBURGH. I would guess that the great majority of our graduate students go into teaching except in some areas. There are some areas of chemistry and some areas of engineering in which there is a great need for people in industry and they get attracted there. I would think that most of our people in mathematics, physics, biology, and in some theoretical science such as metallurgy would go into teaching, and I think we take an attitude as a graduate school that we are hoping our greatest contribution, our reason in a sense for being engaged in this is to provide good teachers for the country. This doesn't mean the lack of desire to provide good people in research, too, because this is an important component of good teaching, particularly in the sciences.

Mr. DADDARIO. Thank you.

Father HESBURGH. I will continue now.

Another group of Foundation education activities which have always been close to my heart are those concerned with improvement of education in the sciences, mathematics, and engineering. These consist of a group of programs designed to improve each of the two fundamental factors involved in education; namely, the effectiveness of the teacher and that of the subject matter which is taught.

As you gentlemen know, these programs collectively are of impressive size, both in dollar expenditure and in number of persons affected by them. The number of teachers who have received additional training is large. The number of students affected indirectly is enormous. These programs have reached into every corner of our country with a major impact at the grassroots level. We do not need to guess about the results. They are self-evident; for example, in the vastly improved preparation with which students enter college—so much improved that our beginning college courses in science have had to be revised to higher levels. What this means, of course, is that our young people are learning much more and more quickly and, therefore, are better prepared than ever before.

One of the most notable of the Foundation's innovations is the so-called institutes program which is aimed at improving and updating of the teacher's substantive knowledge of the field of science being taught. It is to be remembered that knowledge in the sciences has been increasing at an enormous rate. In many cases, the teacher's

last training in the field was taken 10 or 20 or even 30 years ago. It is understandable, therefore, that many such teachers, whose training dates from another era, find it difficult to teach the science of today.

Accordingly, the institutes supported by the Foundation are designed to assist the teachers to catch up and to update their own knowledge of recent developments in their fields. Over the years, these institutes have been heavily concentrated at the high school teacher level—a concentration that has been quite conscious and deliberate on our part. For it is in the high school that science first appears in the curriculum in the form of specific courses taught by special teachers. Therefore, the high school is not only a crucial point in science education but, also, it is the stage of the educational process in which the greatest and most effective impact could be achieved rapidly by teacher improvement.

It is important that students be subjected to good teaching at the earliest possible level. Education is a cumulative process, each level building on the previous ones. What can be taught at one level is determined to a considerable extent by what has been already taught and how it has been taught at earlier stages. This is most clearly exemplified by mathematics, which is a separately identified subject as early as the first grade. It is even more cumulative in character than some of the other subjects and it is studied by all students for a number of years. Furthermore, a mathematical foundation is necessary for most other fields of science—and a knowledge of mathematics is useful in all walks of life. Hence, the Foundation's teachers institutes have consciously given special attention to this subject. Indeed, in the case of institutes for elementary school teachers, those devoted to mathematics predominate.

Effective as the teacher institutes may be, however, they do not solve all problems. I remind you that in the institutes programs the teachers apply as individuals and are selected as individuals. This, we believe, is as it should be. But it is a fact that something like half of the high school teachers of science and mathematics have never even sought admission to any of these teacher programs. Also, there is a continuing stream of new teachers entering the classroom and many of these have had less than adequate preparation at the outset. Much will have to be done about these matters. The Foundation is seeking intelligent ways to help with them. There are no easy solutions to such problems but the search for them continues.

While speaking of improvement of science education, I should mention that, in addition to increasing the knowledge and ability of the teachers, it is important that they be provided with the best possible modern, up-to-date curricular materials and aids. I refer to textbooks, laboratory manuals, movie filmstrips, laboratory equipment, demonstration materials, and so on. These are being given serious attention by the course content improvement programs of the Foundation with notable success. I believe that the college physics professors of the country, for example, would heartily agree that since the introduction of the so-called physical science study committee high school physics curriculums, many students come to college enormously better prepared in physics than ever before. The same is true for chemistry, biology, and mathematics and now it is spreading to other fields. This, too, has contributed much to the educational revolution which has oc-

curred in the last 8 to 10 years. I am proud that, in large measure, the Foundation was responsible for these advances.

Time does not permit discussion of all of the Foundation's science education programs. I have mentioned only a few. But I may say that all of them are aimed at a single objective which is to assure our young people the maximum opportunity for development of their scientific potential. This is a worthy goal. It is my belief that these programs are doing a great deal to help us reach that goal.

Mr. Chairman, in the final portion of my testimony I should like to touch upon an area which, I am sure, is of interest to your committee. I refer to the relationship between the Foundation and the institutions of higher education—the universities and colleges of the country. I believe it is safe to say in this connection that, in the main, these relationships have been harmonious and beneficial both to the institutions and to the Government. The Foundation is held in high esteem by the institutions of higher education and by their faculty members. It is considered a real mark of prestige and accomplishment to receive a Foundation grant. This is so because it is known throughout the academic world that the Foundation gives careful and fair evaluation to every request and that, within the limitations of the funds placed at its disposal, it attempts to support those of the highest quality. Of course, with many more requests than it can support, there are many disappointed proposers of projects. But, on the whole, even those who are thus disappointed agree that the procedures and consideration have been fair and that the administration is honest and just.

Many persons in academic circles would like to see the Foundation receive larger appropriations so that it might support a larger proportion of the worthy projects submitted to it. It is recognized that although the Foundation's budget has grown considerably in these first 15 years, it has not grown sufficiently rapid, particularly if one bears in mind that it is the only Federal agency with responsibility for nonmission-oriented basic research and for the welfare of education in the sciences.

Of course, the philosophy of supporting the highest quality projects results in a considerable proportion of the grants being awarded to a few institutions. Although this is understandable, nevertheless it tends to create the problem of geographical, or, more correctly, institutional concentration of funds. This is a matter which has been of concern to many of us who are involved in the university life of the country just as it has been of concern to this committee. We must continue to seek ways by which we can alleviate this situation to some extent. But it is obvious that simply dividing the available funds on a formula basis without regard to quality is not the way to do it. We must strive to achieve two goals. The first is to maintain and nourish those centers of high quality in research and education that already exist. Surely, it will not be to our advantage to cut the peaks of quality down to those of lower level. These high-quality institutions not only provide a goal toward which the others can aspire and work but also they are the sources of the teachers and researchers who, coming to the less well developed institutions, will help them to improve their own level of excellence.

Our second problem is to assist, wherever we can, the attainment of higher levels of excellence. This, it seems to me, promises the greatest possibility of alleviating the problem of institutional concentration of funds. And this is why all of us on the National Science Board are so enthusiastic about the Foundation's new activity which we call the science development program. This program, which has just completed its first full year of active life, is designed to assist universities to develop groups of science departments to a higher level of quality. The institution must demonstrate that it already possesses a reasonable nucleus of quality in the areas to be developed and that it has the will, the resources and the planning required to maintain them at the higher level which the Foundation grant will help them to achieve.

Already, during this last year, the Foundation awarded such science development grants to 10 institutions in various parts of the country. As you know, it is intended that during the current fiscal year another group of institutions will be helped. Thus, over a period of a few years, centers or nuclei of quality can be built where previously only potential existed. I believe this program holds great promise for the institutions of higher education and, through them, for the country as a whole.

Mr. Chairman, as is evident from my remarks, I am very proud—of the accomplishments of the National Science Foundation during its first 15 years. I believe that its establishment 15 years ago acknowledged a new dimension in the concern of the Federal Government for a previously largely ignored but most important segment of our national life. This acknowledgment has borne a very rich and beneficial harvest of direct and indirect consequences. Our research enterprise has been enormously strengthened. Basic research, the very foundation of our applied technological progress as well as of our understanding of man and his environment, has been given a respectable place—the place it deserves and must have.

Our scientific and technological establishment is now the strongest of all the nations of the world. Our educational enterprise has been accorded renewed recognition and consideration and, in the sciences and mathematics, has been given vigorous stimulation toward improvement. This now is being carried over to nonscientific areas with great benefit. The teachers of the country, once looked down upon, are more and more being recognized for the important role they play with the result that we can hope that additional first-rate people will make this field of activity their career choices.

In all these beneficial accomplishments, the National Science Foundation has played an important role. I can say to you most sincerely that I am proud to have been a member of its Board during 11 of its 15 years and to have thus been associated with its accomplishments. All of us look forward to the continued success of the Foundation in the important role it has to play in the future. And all of us sincerely hope that in the years ahead the Foundation will continue to enjoy the same fine support of Congress that it has had in the past.

I should not conclude this without thanking each of you gentlemen for your wonderful interest and the time you are spending to understand this enterprise because I think it one of the most important in our country.

Mr. DADDARIO. Father Hesburgh, would you describe in more detail the relationship of the National Science Board to the Director? How often do you meet? What is your relationship? What kind of staff help do you get, and where do you get it from?

Father HESBURGH. I would be very happy to do that, Mr. Chairman.

The relationship has changed somewhat over the years because, as you gentlemen can imagine, 11 years ago when I first went on the Board we had a budget, if my memory serves me well, somewhere in the area of $6 to $8 million, and now, as you know, we are creeping up on a half billion dollars, maybe not creeping.

But in any event it was a different kind of operation in the early days because we could meet roughly once a month, we could look at every single activity the Foundation was doing. There was not the sweep of different projects, and all of us I think on the Board in those days felt it was like running a corner drugstore where everybody that worked in the store knew what was going on.

As that budget started to grow, and, of course, it took an enormous jump after sputnik, as did many other science and research and educational activities, then we somehow had to change the balance, in our activities. We decided to leave to the discretion of the Director grants for projects up to a certain amount of money, a quarter of a million dollars. The Director would then report to us what activities he took upon himself to decide between board meetings.

This was, I believe, a wise move because it allowed us then to get into what you might call the areas of basic policy, looking into such specific things as university-Government relationships which, as you know, is a very important policy matter for the Government and for the universities and for the growth in science and education.

I happen to be vice chairman of the new Committee 3 of the Board. We meet every month. We comprise one-third of the members of the Board, eight members. We call ourselves at times the blue sky committee because we are trying to look ahead 10 years, first of all to assess what we have done in the way of large scientific endeavor and then where we should be going for the best growth of the Foundation.

In this way, instead of sitting down and looking at this grantee of the Foundation and this small research grant for $10,000 and this little thing here, we are looking at the broad issues which we think the Congress intended when it created a National Science Board.

To get specifically to your question, the relationship between the Director and the Board, I have mentioned the historical genesis of our relationship, where in the past before the law was amended the Director was ex officio, a nonvoting member of the Board. There were 24 members of the Board plus the Director who always sat with us but did not have a vote.

I think the Congress did a good thing in making him a full voting member of the Board and chairman of its executive committee, and I can say that it did not affect our relationship in any way whatever because we always had in this particular activity of the National Science Foundation Board a very fine relationship between the Board members and the Director, and making him actually ex officio, a full voting member of the Board, did not seem to affect that relationship at all.

I serve on a great number of boards and I think it is just a matter of administration that there is always in almost every human organization, be it a university or a business organization or any type of human organization, a bit of tension between the man who is actually the chief executive officer, the director, if you will, and the people who establish basic policy.

I can honestly say of all the various boards I have had the privilege of serving on, there is none which has operated with as much amity and accord and real discussion and consideration of basic policy than the National Science Board. When I joined the Board, I didn't think it possible for 24 people to have a discussion. It seemed like too many people, and there have been discussions over the years that maybe we ought to cut down the number of members on the Board. The fact is that the work gets done. I think it gets done with some intelligence and some wisdom. I wouldn't want to say that we don't make any mistakes because I am sure you do and we do at times.

Mr. DADDARIO. Congress also has been known to make mistakes at times.

Father HESBURGH. The fact is this association has been a fruitful one. It has only involved two Directors, Dr. Alan Waterman in the earlier days, and in the last couple of years Dr. Leland Haworth, and I would guess you would have to look very far to find a better operating relationship between an operation and the policymaking board than this one.

Mr. DADDARIO. These special committees meet once a month?

Father HESBURGH. That is correct.

Mr. DADDARIO. How often does the Board meet?

Father HESBURGH. We used to meet once a month. Now with the establishment of these special committees and the delegation of authority we find we can meet with the director less frequently, I would say six times a year.

Mr. DADDARIO. Whom do you look to to prepare information?

Father HESBURGH. This is the staff. We get so much information that again I don't know of any outside activity that I have where I have to do more reading than for the National Science Board.

We have enormously well prepared papers. I would say every time we come to the Board meeting, we have a stack of papers about 4 inches high. People are very good about doing their homework, and the staff working on the Foundation has always been first-rate to my knowledge.

If we want special information, for example, on these special committee meetings, all we have to do is ask the staff people, the appropriate staff person through the Director of course, for this information and we will have well prepared booklets on any subject regarding the Foundation's activity.

Mr. DADDARIO. Is there any problem because you get this information from the same people who are in fact advocating a position? Does it give you as a member of the Board, or does it give the whole Board, the kind of objective preparation that it needs?

Father HESBURGH. I have never felt that problem, Mr. Chairman, for this reason. This has been a very dynamic activity. It has grown very well, but in the early days we kept the brakes on, if you can believe this, so we could feel our way in these great areas of activity,

so that we could grow organically and not like Topsy in every direction at once.

When the time came to expand in this or that activity, such as course content or institute work or this or that particular type of activity, atmospheric science, which you will hear more about, or radio astronomy or something else, we always got a good number of alternate possibilities.

I think this has been where the staff has been most helpful to us. They rarely come to us and say we just want to do this. They say here are several new programs. We have a chance to discuss these programs, to judge for ourselves which ones we think are best, and I would say that it is a reasonably rare thing that the staff comes to us as advocates. They normally come to us with the best and most intelligent shopping list that they can find of what we are trying to get done, and we have considerable freedom in making up our minds as a board as to what programs we think are best.

The only real problem, as I said, with an activity this broad is to try to stay on top of all of it, and I must say we have been enormously well informed.

Mr. DADDARIO. What is your view, Father Hesburgh, as to the distribution of the scientific disciplines on the Board? Is it balanced sufficiently?

Father HESBURGH. This is a difficult problem in some ways because, as you can understand with a board that renews one-third of its membership every couple of years. It is quite difficult to get an even balance, and I think it would be preposterous of me to say that we are always in the best possible balance.

If I could tell you a funny story. When I first got the call from the President's office about whether or not I would accept membership on this Board, I told him I thought he had a mistaken idea, that my background had been mostly in philosophy and theology and somewhat in social science and not in the physical sciences at all.

Speaking of background on the Board, President Eisenhower at that time said he wanted someone on the Board with a philosophical and theological point of view. I didn't know exactly why, but I couldn't argue with him, so I said all right, and I have found that the Science Board has provided me with an enormous education in the whole sweep of modern science and basic research in our day. While we do have people on the Board who are highly qualified in physics, chemistry, biology, mathematics, and the social sciences and the various areas that we cover, we are not without some expertise in any of these areas. The main expertise we have is a total interest in the scientific and research endeavor.

It would seem to me that what you would want on this Board is not highly trained specialists, although we do have these—we have a Nobel Prize winner in biochemistry and that sort of thing—but what you really want on that Board is people who will take public responsibility with some background and knowledge and expertise on the total scientific effort as regards education and research. You really want some vision and depth and some concern for education and research.

Mr. DADDARIO. As you have moved ahead over the course of these years and enlarged your activities within the scientific community, how have you seen the National Science Foundation's relationship with the National Academy and OST and PSAC develop?

Father HESBURGH. That is a pretty big one to answer, Mr. Chairman. Let me try.

First of all, we have always had very amicable relations with the Academy. I suppose that one reason is that during the early years I was on the Board our Chairman at that time, Dr. Detlev Bronk, was both the president of the Academy and Chairman of the National Science Board for a period of time. There are very few Detlev Bronks in this country, but he was able to pull it off I think, and during that time we all got to learn more about the Academy.

I believe the Academy has a very strategic role to play in this country and of course it is much older than the Foundation, and I think in many areas where we have needed objective guidance the Academy has certainly played a very important role in giving this intelligent guidance.

I think most recently in the whole area of high energy physics the Academy has performed an enormously useful role in bringing about 30 of the top universities in this country into a national organization for the prosecution of high energy physics and the management of a 200 Bev. accelerator facility. Only the Academy could have done something like that.

I would say that our relationship with the Academy as far as I am concerned as a Board member, it is a place you can always turn to for objective and wise advice of the highest order, and that it has increasingly over the years played a very important role in the growth of scientific research, and I would add, a scientific point of view on where this country is going in all areas of science, because it comprises in its membership the cream of our scientific talent.

Now regarding the other activities I haven't felt any great tension. I think I could say as one thing that might be informative of the members of this committee that in the days following sputnik and in the days when we had to move quickly to upgrade scientific education and research in this country, especially basic research, we got enormous support from the President's science adviser, whether you refer to Mr. Killian or Dr. Kistiakowsky or Dr. Wiesner or presently Dr. Hornig. I found that these people looked upon the Science Foundation as a center for moving forward in scientific education and research, and they were very helpful to us in projecting our program and of assuring us of the full backing of the Office of the President. There were many times we moved forward more expeditiously and I hope more intelligently than we could have without their support. With PSAC and the Federal Council and all the other agencies, this often gives us a very good sounding board for decisions we must make. For example, to show you how interlocking these activities are, recently there was the Academy report on ground-based astronomy which was of great interest to Committee 3 of the Foundation's Board. First of all, we had something to talk about because the Academy had projected this written report. Secondly, this report was discussed by all of the Federal Council, which was again most helpful to us because it gave us some idea of how the total activity in astronomy was divided throughout the whole Government and how we could perhaps eliminate overlap and decide who could possibly take on the organic growth of astronomy for the years ahead to be sure we didn't drop behind, which is very important in the space age.

Thirdly, when we came down to decide what the Foundation's role was, we didn't come to this subject completely without information because we had a fine report, we had the reaction of the Federal Council to it, we knew what the general reaction of the Office of the President's Science Adviser was, and we could come with our own responsibility as Board members to say what the involvement of the Foundation should be in our judgment, and this was referred to the whole Board. To summarize in one word, I would say our relationship with these other bodies has been one of cooperation and as far as I am concerned fruitful cooperation.

Mr. DADDARIO. Mr. Roush.

Mr. ROUSH. Father Hesburgh, I am of the belief that the national interest is better served if we had a better geographical distribution of our research and development funds which come from the Federal Government. Would you agree with that?

Father HESBURGH. I would agree with one qualification. I think that what you express, and which I would agree with, is an ideal, and I think one of the key problems of the National Science Foundation is to work toward this ideal. When I say it is an ideal, I put it that if we could all close our eyes and say this is the scientific and educational structure of this country, it would be great to have strength in every part of the country, but the simple fact is for many casual historical reasons that are very hard to plot you get centers of excellence all over the country, and science is no exception, and science education and research is no exception. For example, in the Midwest we have been bothered for a long time by the fact that we turn out about 32 percent of all of the Ph. D.'s in science and technology and yet we get nowhere that proportion of research grants, and I am sure many of the people we educate are promoting activities on the east and west coasts. In the Midwest, if I might speak to you as a compatriot here—although I am originally a New Yorker, I have lived most of my adult life in the Midwest—I think we hope we can create greater strength there since we have the educational strength, we hope we can have a greater proportion of the research in the total country. But I say this is an ideal, and I believe that the Science Foundation is uniquely set up to move toward this ideal from the present reality.

Mr. ROUSH. You would agree this is a goal that we should work toward?

Father HESBURGH. It is a goal. We are working toward this goal in several practical ways.

Mr. ROUSH. Is there a relationship between the geographical spread of institutional centers of excellence and the geographical distribution of the Federal research dollar?

Father HESBURGH. There should be I believe, and I would guess that if you look at some of the very interesting graphs that have been gotten out on NSF research money, we do them by sections of the country, and we show the production of Ph. D.'s and the percentage of research. I think you will find a fairly good correlation there. I took your question on the Federal dollar as not just NSF but the total Federal dollar, and this gets into NASA, DOD, and many other areas.

Mr. ROUSH. The National Science Foundation does very well, and I think it is commendable that they are working toward this goal.

However, the fact that you related just a moment ago that the Midwest, for example, produces 32 percent of the Ph. D.'s in science and engineering I believe casts doubt on whether or not there is a relationship between centers of excellence in the educational institutions and the geographical spread of the research dollar. Now, looking at this the other way, does the concentration of the Federal research dollar in certain areas of the country have a tendency to pull away from other areas of the country the centers of excellence or their personnel, and is there a danger that this would happen?

Father HESBURGH. Yes, this is always a danger. It seems to me that this country is large enough that we can have an organic growth of science and education in the country. The danger you mention is true I think and does happen on occasion. We often have trouble keeping a top physicist if all of the high-energy physics facilities are on the east and west coasts except the new one at Argonne National Laboratories. I think what NSF is doing, though, and this gives me great heart and I think it is one of the most promising things we are doing, you see following on the Seaborg report and the Gililland report, which pointed up instead of 20 centers of excellence for graduate training in science and research a country of this size ought to have 50, 80, or 100, we have set out deliberately to create these centers of excellence by our science development grants. What we are trying to do is to spot them right across this country, and I think if you look at the spread of grants that have already been given and those that are being considered, you will see that there is a wide geographical spread, that we are creating centers of excellence in every part of this country, and that the hope for the years to come is that these grants will not just spread the graduate student but will spread the research and the research support. But I must say loud and clear, because I think I owe it to my own commitment to excellence, that you don't build up a country by chopping the tops off the mountains and filling up all the valleys and coming up with an eveness or a levelness throughout the whole country. I think you keep the peaks and you support the peaks for what they do to inspire the whole country to aim at the excellence that these peaks have achieved, and you build up some more peaks. I am for building peaks rather than building levelness and filling in valleys.

Mr. ROUSH. I am, too, heartened by the work that is being done by the National Science Foundation in this regard.

Mr. Chairman, I would like to discuss an area in which some of my colleagues have been asking questions. I have a question or two that concerns the social sciences. You mention this on the beginning of page 5 of your testimony. First, let me ask you if history is a social science?

Father HESBURGH. You could get a lot of argument on that.

Mr. ROUSH. I always thought it was.

Father HESBURGH. There are some people who say it is and there are some who say it isn't. I have never really gotten deeply into the argument, but I say you can write it both ways nowadays. There are some historians that don't want to be social scientists and there are others who think they are.

Mr. ROUSH. The National Science Foundation must take the view that it is not a science?

Father HESBURGH. We don't take the view that it is not a science. We take the view that there are certain aspects of history such as the history of science which are enormously important for an understanding of the scientific endeavor in man's history, and we support projects in the history of science, not in history per se.

Mr. ROUSH. But you do support projects in political science?

Father HESBURGH. That is correct.

Mr. DAVIS. If the gentleman will yield—would archeology and anthropology be a form of history?

Father HESBURGH. Of course. In a sense for ancient history it is all you have for a real base, where there are no written documents, where you have to go on artifacts.

Mr. ROUSH. I had occasion to call the National Science Foundation yesterday relative to an inquiry received from a constituent who was interested in doing something that pertained to history. This was the answer I received, and I wanted to check with you to see that it was correct. I noticed a little conflict between your testimony and our report, "the National Science Foundation—A General Review of Its First 15 Years." You say that the National Science Foundation supports research in anthropology, economics, psychology, sociology, political science, geography, and linguistics. However, I note in this report under the support which is given to social sciences that we have only listed anthropology, economics, sociology, and history and philosophy of science at those areas having received grants since 1961. Now, are these which you have mentioned included in those which I have related as appearing in this document? Does NSF have grants in political science, for example?

Father HESBURGH. Yes.

Mr. ROUSH. And in linguistics?

Father HESBURGH. Yes. There are two ways of reading this. Our normal reports will mention under social science anthropological, economic, and sociological science, history and philosophy of science, and special projects. Most economic and sociological proposals are included under economic science; linguistics under anthropological and sociological depending on the particular project. Political science and social psychology are listed under sociological science. Some of these more recent additions to our program, such as, for example, political science, would not be represented as helpful as where we started in basic economics and sociology in the early days when we established the new division. You see, when the act was written there was not included a division of social science. Dr. Bronk, a good number of years ago, I hesitate to give the exact year because my memory may fail me on this, but a number of years ago, I would say about 6 years ago, Dr. Bronk, who was then Chairman of the Board, established a special Board committee to study what we should do in the area of social science. We established first an Office of Social Science Research and then a year or two following that we established by full Board consent a Division of Social Science Research, with a divisional committee and with a Director who is present here today, Dr. Howard Hines. As this Division grew in the normal organic fashion I mentioned regarding the whole growth of the Foundation, we gradually would add other subjects. The last subject to my knowledge that we added was political science.

Mr. ROUSH. Are you still chairman of this committee?

Father HESBURGH. No; this Board committee was disbanded when we reorganized our Board into three basic committees. But the fact was that during those years up to the time the division was established I was chairman.

Mr. ROUSH. Do you feel that enough of the Board's funds have been channeled into the science of social studies?

Father HESBURGH. We on the Board feel very frustrated at times because we can grant such a small proportion of the worthy grants that we have. In other words, if you take the total number of grants that we receive and given the criteria of quality that are put against them for judgment, there are a number of them that we would reject because we don't think they have sufficient quality. But on the other hand, of those that have quality we are only able to give a reasonably small proportion of them, generally we would be lucky if we could give half of the grants that are really worthy of being approved. Now in social science what we have tried to do, and again I think this reflects the philosophy of the Board in everything we have undertaken, we have tried not to just rush headlong into a new program, and when the Board approved the Division of Social Sciences, it began at a fairly low level around $2 million, as I recall. When we were first talking about it, we thought we would try to double that every year, and we have now reached about $10 million expenditure. Granting this is not a lot of money compared to our total budget, and granting that we could spend a lot more money because we are getting more requests every year, we have tried to have a controlled growth, if you will, and a growth based particularly on quality judgment, and the only fair thing I can tell you is that we have a lot more good grants than we have money to support them, and not only can we not give a certain proportion of those good grants that we have on hand every year, and they are growing every year, but we also cannot grant the amount of money requested to do the job.

Mr. ROUSH. I note that since 1962 the percentage of awards made as to the proposals made has gone down slightly in this particular area while in the area of the physical sciences it has gone up. Does this mean that we are going away from support in this area rather than maintaining a certain level?

Father HESBURGH. No; I would not say that. I think we are trying to maintain a level, but again you get certain fixed commitments in the physical science that don't exist in the social sciences. For example, if you are running a national laboratory for radio astronomy, for optical science, for oceanography, for Antarctic research, for Mohole, etc., these are pretty fixed commitments, and some of them are not even. For Mohole, for example, the budget will go up and it will drop down. The fact is in social science there is a very strong emphasis in graduate fellowships, because the key to growth in any science is the development of people who have doctoral studies in these sciences, who are qualified to go out and to be university professors or to work in other functions, and we are trying desperately to build up the highly developed core of social scientists in our country. So we have very heavy emphasis on graduate support in this area. The second thing is the normal grant in social science which will not have anywhere near

the dollar volume as the grant in physical science, because in social science there is not the emphasis on physical equipment that comes in the physical sciences. Often, it is a question of allowing a person to travel where he can study some ruins, if you will, or to travel where he can study some particular kind of social organization in a cultural anthropological study.

Mr. ROUSH. Wouldn't this mean in this particular area that more assistance and more attention could be given to the smaller college and university in the area of social sciences?

Father HESBURGH. It certainly could. And I think consonant with all of our other developments in the Foundation this is what we are trying to do over the long run. There are a great number, if you look at the current grants, for example, out of 770 research grants from the Division of Social Sciences activity, at the close of the year 1965, 690 of these were to colleges and universities, and if you break that down further, at the close of fiscal 1965, one or more social science grants were held by 335 different departments in 125 academic institutions, which is a fairly good spread for this Division given the fact that it is our latest created Division. I hope we can get more support for social science. I think it is enormously important. I think if you take a look at the history of social science support in this country you will find that when we created the Division we were really filling a vacuum because if you take the large foundations of this country, I am talking now of the private foundations, some of them have a history of getting into social science and then getting out, and when the very large ones get in, the smaller ones tend to get out feeling that the larger ones are going to carry the role. At the time we got to considering social science in the National Science Foundation, one of the large foundations had gotten very heavily involved in social science, even to the extent of erecting a national facility in social science, and then, having somewhat withdrawn, leaving a vacuum in this field. When the Science Foundation came into filling this vacuum for very legitimate reasons, since we had the authority in the act to do so, then we were in a sense swamped by these people who had very legitimate research needs and very legitimate study needs for graduate fellowships, and we were one of the few agencies who could fund these needs.

Mr. ROUSH. Mr. Chairman, I am sorry to take so much time. I would like to close with a comment of my own and to explain the reason for pursuing this. I know that one of the great national problems we have today is the problem of crime. In attempting to get some background on this problem, I have been amazed and somewhat shocked to find that there is very little research being done in the field of human behavior and in the sciences which are involved in the handling of our crime problem. I see in this a real potential for some agency of the Government and for various research centers of this country which might be capable of dealing with the problem. I am hopeful that sometime in the future it might receive some attention.

Thank you, Mr. Chairman.

Mr. DADDARIO. Mr. Mosher.

Mr. MOSHER. Mr. Chairman, it seems to me that Father Hesburgh's testimony concerning the Foundation has been very encouraging and most significantly so because of his long experience on the Board.

Personally, I want to say that I am very happy that with his special background and the point of view he represented that he has been on that Board. I only have one question.

Father, at some point in your testimony you suggested that some people had felt that the Board might be smaller. You personally testified to the efficiency of the way it has operated and its effectiveness. Do you want to go into that a little bit more thoroughly? If you had your druthers, would you run a smaller board or a larger board perhaps?

Father HESBURGH. Mr. Mosher, when I went on the Board in the first instance, I said how is it possible for 24 people to do business, because many of the boards I happened to be on at that time were smaller boards. But I soon found out on the National Science Board if someone hasn't something significant to say, he doesn't say anything. The group has a great cohesion, because many of the members are together for 6 to 12 years, depending on whether they are reappointed to the Board, and people look to different members of the Board for different points of view and different kinds of expertise that bear upon the subject under discussion. The Board has a very good committee structure. There is an enormous amount of time put on outside of Board meetings in committees. We have had a very capable staff. They have given us information in amplitude, by that, there is no stinginess about the paperwork there. We get everything we need and with a full look at it. So it is a rather unique board because it is this size, but I think its size brings it some of the spread of point of view and some of the spread of expertise that was questioned before, and it also gives it a very good geographical spread. In other words, we have every part of the country represented on this Board. We have a member of the State of Washington right now, to give you one extremity. We have almost always had members from the State of Texas. We have had members from the east coast, we have had members from the Midwest, we have had members from the South. Geographically it is a very fine spread and always has been, and as a result provided that the Board continues to operate with the Director and with with the same kind of relationship it has had in the past, I think it is a good size, and I think most of us felt when the question was raised of, say, cutting it down to 18 members or less, we felt this would be a mistake.

Mr. MOSHER. This must mean then that the various occupants of the White House, have been wisely concerned in selections to the Board?

Father HESBURGH. I would say so. I would think over the years there have been very few selections to the Board that the Board itself would not have selected if they had a complete choice in the matter. They were allowed to recommend.

Mr. MOSHER. Does the White House ask for the Board's recommendation?

Father HESBURGH. Yes. They always have in the past, and I would assume they would continue to do so. They also ask for recommendations from other large boards such as the American Council on Education.

Mr. MOSHER. Just one more question. Do you think the Board will look with favor on other projects like Mohole?

Father HESBURGH. I think there is a constant concern on the Board that there are large areas of science in which the country might be falling behind, and when we perceive such an area, be it oceanography or getting at the earth's crust, which is a very exciting project scientifically and something we know very little about at the moment, or atmospheric science, or this whole area I mentioned earlier of astronomy, or the wonderful research going on in the Antarctic, not just the research itself but the cooperation of so many nations in the project, we believe we should undertake these projects, but at the same time I think everyone on the Board feels a reluctance to get into a big project because a big project tends to cut into what we consider our main show, if you will, which is basic research in all the universities of the country.

Mr. MOSHER. It can distort your program?

Father HESBURGH. And the educational projects. We have generally had good understanding from the Congress on this, that with the addition of these large projects they have enlarged our budget so we don't completely distort the total program, but I think all of us feel at times we would like to have a little more free money for basic research and for some of our educational projects, and particularly we would like to get good support in the science development project, because this is institutional support for institutional growth in creating these centers of excellence on a much larger magnitude and geographic spread throughout the country.

Mr. MOSHER. Father, when there are large gaps that need to be filled, do you think the responsibility of the Foundation is to step in?

Father HESBURGH. I think it has to. It is the only one that can do this. When we made a study of astronomy, it was the Board's conclusion, after making a very complete study that went over several months, taking a lot of time of individual Board members and staff people, that there was really no other agency of the Government that could do this on an organic planned fashion so we weren't duplicating or overlapping but we were getting what this country would really need in a consistent program of land-based astronomy over the next 10 years. I think we have very little choice in this matter because there are areas which tend to slip behind and there are new areas that are coming into science that have to be supported and given the flexibility of the Foundation and the decision of its Board, it seems to me that the only answer is, and I see no way of avoiding this, that the Foundation budget will simply have to grow as it takes account of these other commitments, especially to see that they don't bite into our very basic commitment to education and basic research.

Mr. DADDARIO. Mr. Davis.

Mr. DAVIS. Mr. Chairman, Father Hesburgh, I first would like to state a few conclusions, that I have formed over the past few years, in order to make my question a little clearer. In the first place, I usually try to go annually to the Westinghouse Science Fair competition in which there are 50 contestants and they select the first-, second-, and third-place prizewinners. The first time or two I was more or less lackadaisical about it because I had assumed that every one of the contestants probably had a Ph. D. for a father and had been indoctrinated ever since he was in kindergarten. However, one night I happened to sit at a table with a boy who, as it turned out, had won the first prize.

I had a chance to talk to him a little about it, and I was astonished to find out that his father took no interest whatsoever in science; I think his father was a shoe salesman.

Two of the contestants, as I recall, came from the same science class in a Miami high school. This impressed me as to the value of a good teacher in a school system.

Second, I would like to mention the fact, as was brought out in testimony when Dr. Keppel testified before us the other day, that the different school districts in the United States are virtually autonomous. It couldn't be brought out any more graphically than it is being now in the Southeast with the implementation of the Civil Rights Act, where the school districts know that they are not going to get any form of Federal funds next year unless they comply with the Civil Rights Act. Dr. Keppel, for example, cannot pick up the telephone and call the State school superintendent of Georgia and find out anything because the State school superintendent cannot exercise power over the local school boards.

Father HESBURGH. There are 200 different districts in Georgia.

Mr. DAVIS. I would have guessed we had more. I represent 14 counties, and some of them have as many as 3 separate school districts.

Father HESBURGH. That is right.

Mr. DAVIS. So, as applied to a national program, we are dealing with a great many separate entities when it comes to trying to bolster the science program in a school.

Now, third, I do not want to take too much time discussing my own district, but it does happen to lie in Appalachia, and the living standards are somewhat below the rest of the country. I have always been very anxious to see the young people take advantage of such opportunities as might exist with the Government or anywhere else. Well, it turns out that we have virtually no applications for scholarships in the natural sciences from my particular district. Yet, that is the area of maximum help as far as the National Science Foundation is concerned.

As a final observation, I do not think there is any finer part of your program than the summer institutes program in which you update the teachers, and, also, the course improvement program. I wonder, however, if your Board has devoted any thought to the problem of providing some sort of incentive to the teachers to attend these institutes and to improve themselves. In other words, since there is no possibility, as I see it, of establishing a line of communication with every independent school board in the country, has the thought occurred to you to explore some way of providing an incentive on the part of the teachers to attend these institutes?

Father HESBURGH. We have, I think, tried to build in the incentive that it is more worthwhile for a teacher, say, to come to one of these institutes and get a reasonable summer salary for doing so than to have to run an ice truck or work in a grocery store, something of this sort. So the big incentive was first of all financial. The other incentive that we felt was important here is that most school districts—perhaps I shouldn't generalize—many school districts have a built-in incentive that with additional educational effort on the part of the individual teacher, the pay scale rises. I think this is a fairly universal phenomenon, at least in those school districts I am familiar with.

In all of this effort of equalizing opportunity today, we could find other means of getting at these teachers, that perhaps it never occurs to them that this possibility is there. I have a feeling—and it is no more than a feeling—that this is maybe a matter of communications. You see in all of the advanced school districts, I am sure every science teacher knows and knows far in advance that these are the possibilities. We allow a wide range of attendance at these so that a teacher, perhaps, in New York State could go out to Colorado, to the university there for a course, and this might do two things.

Mr. DAVIS. That I didn't realize.

Father HESBURGH. This could do two things. It gives the teacher a chance for a change of scenery, which I think they need every once in awhile, and, also, new science in a science department in which they can upgrade themselves. It would be possible for teachers in your State to go to some other State entirely—North, South, East, or West—and apply. I have an impression where you get a school district that is a little depressed because of the economic-social situation of the teachers, that it is just quite possible that the word doesn't get around as much as you would like it to, and I don't think this is for fault of publishing the word and trying to get it out, because I am sure we have used every possible mechanism to get this word out to all the teachers of the country, and all the professional societies for teachers have the word on this, but it is always possible to do a better job and maybe this is something we ought to give a little attention to. I would be very happy to take a look at it, and I will follow up on it.

Mr. DAVIS. I would appreciate it. Isn't it also quite likely that the prestige of being a teacher continues to grow?

Father HESBURGH. That is true.

Mr. DAVIS. In times past I know in my part of the country it was thought of as a job for a woman, and it was very poorly paid. Education was thought of as something you could more or less button up and say, "I am educated. I have finished learning."

Father HESBURGH. This day is gone forever.

Mr. DAVIS. I think, too, since this day is gone, as soon as that realization sinks into the public consciousness the prestige of being a teacher will increase considerably.

Father HESBURGH. I think the great thing is you find in the Foundation all of the mechanisms for getting at the very problem you mentioned, and I think that our only problem is to make sure we get a greater response, because I think, as I mentioned in my paper, about half of the teachers of the country have never applied to come to an institute. Some of them may have a family situation that makes this impossible. They may not be able to travel. They may not live near a university where they are teaching. But we have, I think, over the years given very wide support throughout all the universities in the South, and I think it wouldn't be necessary to travel too far. Although they could go to the North, South, East, or West, as I said, there is a great deal of mix. At our own university I have been surprised to find when I have talked to teachers that I have met some from the Atlanta district, coming up from the South, who have possibly come up for a change of scenery, perhaps.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. No questions.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I have a few questions, but I think time is running short on us. You refer to the Director being appointed by, and responsible to, the President, and that the Director of the Foundation is a member of the Board. I also presume he is responsible to the Board. I am curious to know the relationship between being responsible to the President and being responsible to the Board.

Father HESBURGH. I have never sensed any problem here, Mr. Vivian, because the Board essentially makes the policy for the Foundation, and the Director over the years to my knowledge has tried to be sensitive to the policy indicated by the Board. Of course, he has a very difficult task in many ways because the staff of the Foundation grows and his problem is to project this policy to all of the members of his staff.

One other thing I haven't mentioned in the testimony, but it is just a practical working relationship, there are very few meetings of our Board that don't have present at them all of the divisional heads of the Foundation's various programs. We do have executive meetings, of course, from time to time, but the fact is that we think it is a very educative thing both for the Board and the staff to have almost an equal number of these members together to be privy to these discussions, because they are there giving us information that we are constantly asking for, and they are there to hear what the Board feels about their programs, the direction it is going, and the quality of it and so forth. So it becomes a little simpler for the director if his staff people are in the room hearing all of the discussions of the Board very periodically, and for them in turn to pass the word to the whole organization.

Mr. VIVIAN. Does Dr. Hornig appear at your Board meetings often?

Father HESBURGH. Only on special occasions. I would think over the years we have had the President's science adviser at the meetings any time we had a question concerning his office or a question in which he could speak to national policy in a broader sense than we could as Board members. There has been always a great cordiality here.

Mr. VIVIAN. How often have conflicts arisen between PSAC and OST?

Father HESBURGH. I would say once the Board knows really what it wants to do and is firm in what it wants to do, there hasn't been any insurmountable conflicts to my knowledge. My own reaction is they have been very helpful to us, these other groups of the Government. I think everyone is generally of the consensus that science and technology is very important in the total growth of the country, that we all have a role to play in this in our various responsibilities, and the real job is one of cooperation, of eliminating overlap, of working together on different levels, and this has been achieved quite well, I think. There are some people who think that science is overorganized, but I haven't seen any real evidence of it.

Mr. VIVIAN. You mention, for example, econometric studies, in which I am very interested. Would this bring you in conflict with the Bureau of the Budget? Would this conflict be resolved through the President's office or Dr. Hornig's office?

Father HESBURGH. No problem there that I know of. Since the very first days of our involvement in social science research, we have been involved in econometrics because it is a field so very closely allied

to the physical sciences. It is a very quantitative science, as you know, and it ties in with many other scientific endeavors. So far we have not had any reaction to my knowledge, any unfavorable reaction to our work in this field. I suppose we ought to be doing a lot more in it, but that is true in every field we are in.

Mr. DADDARIO. Father Hesburgh, I want to thank you on behalf of the committee for coming here today. I hope we might be able to send some additional questions to you.[1] There are many more to which we would like to have answers.

Father HESBURGH. I would be very happy to do that, Mr. Chairman. In any way at all I can help, you can call on me.

One point I would like to underline, if I might, in my testimony, and I think this is really the acid test. If there is going to be better education in the sciences and better basic research in the sciences, somehow all the universities in the country are going to have to be involved, and certainly because of the cost the Government and the Congress is going to have to be involved. My guess is that the nicest thing you can say about the National Science Foundation is that the universities like it, the universities feel at home working with it, they have felt in the collegiate slang of our day that there is very little Mickey Mouse that goes on between the university and the Science Foundation. There has been a great deal of trust that the university will behave themselves and be accountable in their activities. I think the universities' feeling toward the Foundation is a very real thing. It doesn't always exist, but it makes a very cordial situation in which Government and universities cooperate in something that is for the total good of the country.

I certainly think that the effort and time you gentlemen are putting on this is going to be very good for our Foundation because we are kind of very proud of it and we don't mind having it looked at. We all think it could be better. All of us who have had the opportunity to appear before you, have been extremely well impressed by the caliber of the questions and your general understanding of the problem.

Mr. DADDARIO. Thank you, Father Hesburgh.

Our next witness is Dr. Walter Orr Roberts, who is the Director of the National Center for Atmospheric Research.

We are not going to cut down on your time, Dr. Roberts. If for any reason we aren't able to finish today, we will make arrangements for you to continue at some other time. However, we might be able to work that out.

I am pleased to welcome you here. It is always a pleasure to have an Amherst man here.

STATEMENT OF DR. WALTER ORR ROBERTS, DIRECTOR, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Dr. ROBERTS. Thank you, Mr. Daddario, members of the subcommittee. I am greatly honored to be able to appear here this morning in order to tell you a little bit about the work of the National Center for Atmospheric Research and to describe the unique partnership we enjoy with the National Science Foundation and with the universities of the Nation.

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

I would say that I have no objections in your breaking in and interrupting me, although since the time is a bit short and my testimony is a bit long, I will try to condense it as I go through.

A vast change is now occurring in our branch of science, which deals with weather, with influences on the earth's atmosphere from space, and with research on the atmospheres of the sun, stars, and other astronomical bodies. In the last 15 years or so, new opportunities have come into view—opportunities to acquire basic knowledge about the earth's atmosphere in which we live, and opportunities to put that new knowledge to use for the benefit of mankind.

Let me try to place in proper perspective the role that NSF has played in this development.

At the end of World War II, increasing numbers of scientists were beginning to consider meteorology as something more than the art of weather prediction. More and more they recognized that if we were to understand the atmosphere—for example, the factors controlling weather and climatic change, the genesis of jetstreams and hurricanes, or the mechanics of air pollution—we would have to do so in terms of the chemical, hydrodynamical, electrical, and other processes at work in the atmosphere. These processes would have to be defined in rigorous mathematical terms, and they would have to be understood as they occur in the atmosphere—interacting with many other processes occurring simultaneously.

For the first time, also just after the war, we began to develop tools commensurate with the scale of the problems of gathering the required data—high-altitude airplanes and balloons, rockets, and satellites, and new and more powerful devices, such as lasers, transistors, and thermistors, for measurement or analysis. In my view, the most important of all these new tools is the electronic computer. Without it, the many processes of the atmosphere, interwoven with fiendish complexity, could never be viewed as a unified system. And until this unified treatment is achieved, I expect progress to be slow in many areas of greatest practical importance. When the basic principles of the high-speed digital computer were first being realized and fully comprehended, at the Institute for Advanced Study in Princeton by John von Neumann and his associates in the lates 1940's, Dr. von Neumann predicted that computers would find their greatest scientific value in the study of the atmosphere. His words are at last beginning to come true.

The critical development, granting these essential new tools, has been the new concept of how to study the atmosphere. The word "interdisciplinary" has perhaps been overworked in science generally. But in the atmospheric sciences, its use is truly merited. Any process in the atmosphere—for example, ice formation in a cloud, or smog formation in a polluted urban area, or the birth of a great tornado-breeding storm system—is the result of many processes simultaneously at work, and they can't be separated out, but must be viewed together. The specialists in these processes normally work in different branches of science—with notable differences of method and subject. It takes a deliberate interdisciplinary push to bring them together.

If you wish to try to devise methods to predict, and perhaps to influence, events in the atmosphere—in order, hopefully, to bring more rain to a region, to reduce the danger of hail, or to dissipate a fog, or

to control air pollution—it is clear that you must launch a complex study involving physicists, chemists, engineers, and mathematicians with a wide variety of specializiations, and that they must form alliances and work together toward the goal.

In the first 10 years after World War II, individual researchers made considerable progress. But the pace was, and still is, too slow. Atmospheric research was woefully short of creative workers who had adequate basic science backgrounds. Educational efforts to produce the next generation of sophisticated researchers were lagging behind the need.

In addition, talented researchers in the universities were lacking facilities of sufficient scale and range to carry out their work. Therefore, a need existed for a new mechanism to serve as a focus for interdisciplinary work, to supply joint-use facilities, and to take an overview of where the science should be going—with the whole atmospheric science community participating. The National Center for Atmospheric Research was created as one significant thrust against this problem.

The next couple of paragraphs deal with the National Academy of Sciences' study issued in 1958 which really led to the formation of NCAR. That report made three recommendations, one of which was for the creation of a national institute for atmospheric research, closely linked to the universities. Dr. Thomas F. Malone of Travelers Insurance Co., was one of the people who participated intensively in that study and in fact in many ways is the "father" of NCAR.

In 1956, spreading concern about the gap between potential and performance in the atmospheric sciences led the National Academy of Sciences to conduct a special study, and out of this study came the idea for the National Center for Atmospheric Research. The Academy's Committee on Meteorology (now called the Committee on Atmospheric Sciences), under the leadership of Lloyd V. Berkner, issued a report in 1958 that stands as a significant milestone in the development of our national effort in the atmospheric sciences.

The National Academy of Sciences' report made three major recommendations. First, the scale of effort in atmospheric research in the universities should, as a priority scientific goal, be increased at once by 50 to 100 percent. Second, the American Meteorological Society should take on a major responsibility to stimulate interest in the atmospheric sciences, so that the Nation's youth might recognize the challenges and opportunities offered by a career in the atmospheric sciences. Third, a national institute for atmospheric research, intimately connected with the Nation's universities, should be established as promptly as possible.

The response to the third recommendation was the establishment of the National Center for Atmospheric Research (NCAR), in Boulder, Colo, in 1960. It is sponsored by the National Science Foundation, and its main financial support comes from a contract between NSF and our management corporation, the University Corp. for Atmospheric Research, or UCAR. We are an independent organization under university-monitored scientific management and direction. We have a broad charter to promote the growth of atmospheric research, in quality and scope, for the national good. The direction of NCAR is vested in me and in my four associate directors; we, in turn, must

not only be responsive to our national public obligations, but must also operate to the satisfaction of our council of members and the board of trustees. By appointment of this board I serve as director and principal officer of UCAR and also as director of NCAR, the scientific center and sole operation of UCAR today.

NCAR, though principally funded by NSF, does receive minor support from other agencies; and its management corporation, UCAR, has property, scientific equipment, and fellowships for graduate study financed by private contributions.

There were originally 13 universities in UCAR when it was established in 1959, and a 14th joined soon thereafter. In 1964, after the corporation had gained in experience, membership in the corporation was opened to any university that met certain graduate education criteria, the existence of a program of graduate study leading to the doctorate in the atmospheric sciences or a closely allied field. Today there are 21 universities in UCAR. Figure 1 shows their names and locations. The institutions span the length and breadth of our Nation from Hawaii to the east coast, from Alaska to Florida.

The UCAR board of trustees has legal responsibility and oversees management and general policy questions. A second body, the UCAR council of members, composed of a leading scientist from each member university, has principal responsibility for reviewing the scientific performance of NCAR, its services to the university community, and its overall goals. The council review procedure is a demanding and objective one involving a large range of scientific examination and justification. For example, I brought along the review document which we have just prepared for the review committee of the council, and this will be a matter of discussion and debate over the entire coming year.

Mr. DADDARIO. Dr. Roberts, is it true that the council's review procedure that you are referring to as being university-controlled, is in fact managed by members of the universities?

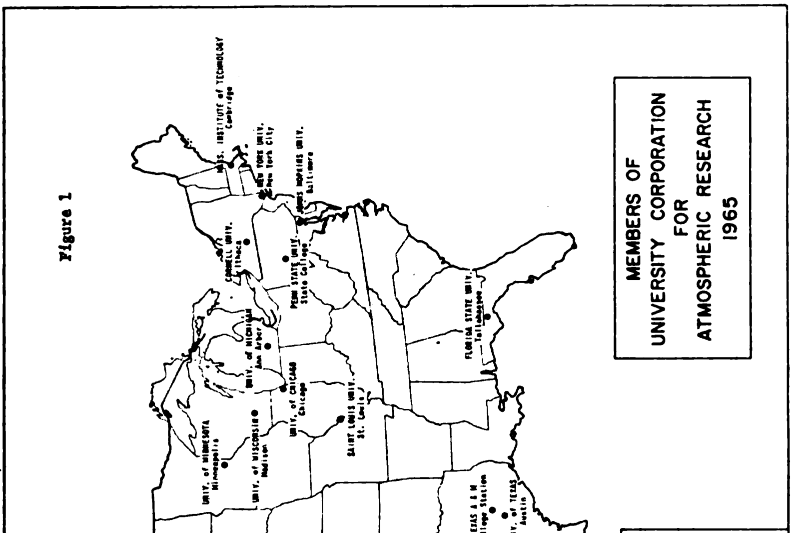
Dr. ROBERTS. The universities are the members. In other words, the universities serve as members of the corporation, and the universities appoint representatives; for example, the members of the board of trustees and the members of the council are officially appointed by the university and not by the board itself.

Mr. DADDARIO. They do not necessarily represent either the academic community or their own university, but they are university-connected people who are specifically involved in atmospheric research and deal closely with you?

Dr. ROBERTS. That is correct, sir. Yes. They represent broad national interests, and not the narrower interests of the individual universities.

The existence of UCAR has helped insure close communication within the university community. But I should emphasize that the facilities and visitor programs of NCAR—following up your point—like those of the other NSF-sponsored national research centers—are open to all scientists, from member universities and nonmember universities, from other private nonprofit research laboratories and from Government laboratories, from this country and abroad. The facilities of NCAR have already served scientists from more than 25 institutions; and during the past year we have had visitors for 2

Figure 1


MEMBERS OF UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH 1965
MASS. INSTITUTE of TECHNOLOGY Cambridge
NEW YORK UNIV. New York City
JOHNS HOPKINS UNIV. Baltimore
CORNELL UNIV. Ithaca
PENN STATE UNIV. State College
FLORIDA STATE UNIV. Tallahassee
UNIV. of MICHIGAN Ann Arbor
UNIV. of CHICAGO Chicago
SAINT LOUIS UNIV. St. Louis
UNIV. of WISCONSIN Madison
UNIV. of MINNESOTA Minneapolis
TEXAS A & M College Station
UNIV. of TEXAS Austin
COLORADO STATE UNIV. Ft. Collins
UNIV. of COLORADO Boulder
UNIV. of UTAH Salt Lake City
UNIV. of ARIZONA Tucson
UNIV. of WASHINGTON Seattle
Berkeley
UNIV. of CALIFORNIA Los Angeles
UNIV. of HAWAII Honolulu
UNIV. of ALASKA College

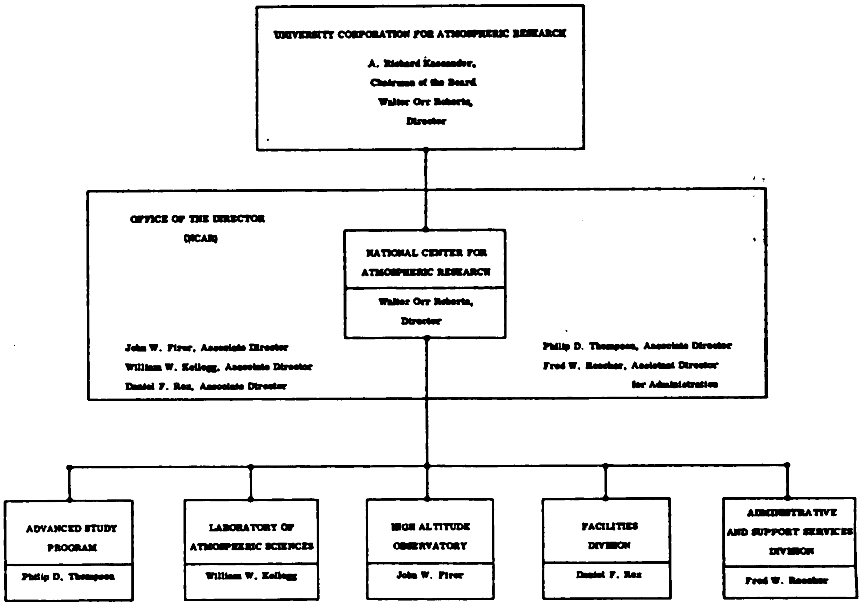
months or more from 35 institutions in this country and approximately 20 countries abroad.

NCAR today has a total staff of approximately 380, and we consider that in size, we are about two-thirds mature. Figure 2 shows a skeleton organizational chart.

Figure 2

ORGANIZATION CHART

THE NATIONAL CENTER FOR ATMOSPHERIC RESEARCH



UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

We conduct basic research of an unclassified nature relevant to a number of areas of highest public concern. These include the cause, prediction, and possible control of weather changes, on all time scales from a few hours to long-term climatic changes; the prediction and control of the upper atmosphere and near space environment; the causes and cure of air contamination on a large scale, etc. We are not an applied research laboratory, but our scientists are deeply concerned that their basic results find prompt application to public use. One might say that our research program is need oriented, even though the payoff may take years to reach.

Speaking a bit to the question you asked Father Hesburgh about motivation to teach, I might say our scientific group, even though we have no teaching responsibility in NCAR, has very strong motivation to teach, and we have worked out arrangements whereby members of our staff can serve as affiliate professors in any university or college in the country, and some of our people have already availed themselves of this opportunity to go and teach for various lengths of time in different universities.

The basic research of NCAR is carried out not only by our resident staff, but also by a sizeable number of visitors, mainly from universities in this country and abroad. Our role, as we see it, is not only to carry out research, but also to stimulate research efforts in the universities on the most critical major problems. Many problems are so complex that only by enlisting the key scientists, wherever they are located, can we mount a suitable attack. This we do through working conferences to examine the current state of knowledge on critical problems, and decide what the next steps should be. This among other measures.

In addition, we have assumed a major responsibility to join forces with the university community in planning and making available large-scale joint-use research facilities not otherwise available.

Perhaps the best way to describe the current status of NCAR is to describe the work in each division.

The laboratory of atmospheric sciences is headed by Dr. William W. Kellogg, who, incidentally, was one of the first people to suggest the development of a weather satellite and worked out many of the details as to what it ought to be. In the laboratory of atmospheric sciences, which is one of two operating research laboratories at NCAR, we have some 35 scientists at the Ph. D. level who work on individual problems and in special project groups—often including visitors from the universities and elsewhere—in three principal fields: atmospheric dynamics, cloud physics, and atmospheric chemistry.

Atmospheric dynamics covers a lot of territory, of course, ranging from the motions of global wind systems to the nature of turbulent eddies that transfer energy between the ground or ocean surface into the first few inches of the atmosphere. A major NCAR effort is underway in the area of dynamics to design a new mathematical model of the atmosphere, building on the experience of dynamicists at UCLA, MIT, the U.S. Weather Bureau, and elsewhere, and carefully planned to supplement but not duplicate their work. From our study and from work in process in the universities and elsewhere, we hope that reliable mathematical models of the atmosphere will eventually be developed which can be used to simulate the atmosphere with enough realism to allow us to experiment in methods of long-range weather prediction and large-scale weather modification.

The next few paragraphs generally describe our research in cloud physics and atmospheric chemistry. Cloud physics is helping us understand the complex nature of the dynamics of the clouds and the rainfall process from clouds, and our ignorance of this subject may have been one of the reasons why cloud seeding has been such a disappointment for many years. I would like to say that atmospheric scientists have found some fascinating things, one of which, for example, tells how one of the old Southwest Indian legends seems to have had some basis; namely, the Indian legend that "droughts promote drought." If I get into that, it would take another hour. It is a most fascinating business.

Mr. DADDARIO. You shouldn't leave us hanging there.

Dr. ROBERTS. In a very brief, brief statement, one of the reasons that clouds over a continental mass don't precipitate easily is because the water droplets are too small and when they collide they bounce off

instead of coalescing. It appears when a drought occurs the soil becomes more favorable to sending into the atmosphere the very particles that cause excessive numbers of droplets to be very, very small, so that when the ground is dry and the sunlight beats down on it, it produces the very conditions that make it unlikely for a given cloud, when it forms, to rain. That, briefly, is the fascinating story.

I point out in my written text, in connection with atmospheric chemistry, that man may already be unwittingly changing the atmosphere, possibly changing it irreversibly by the injection of the jet airplane combustion products into the atmosphere and by other accidental means. If this is so, the implications of this unwitting weather modification may be a problem even more serious than the problem of air pollution, which, of course, is an area in which we also have a deep interest. In each of these cases, basic research is the essential key to information required to deal with these problems.

Cloud physics is, I believe, a widely known term today. It deals mainly with the formation of clouds and the complex manner in which small droplets condense and then coalesce into large enough drops to fall out of the cloud. It is a fascinating area. The production, for example, of rain from a shower or thunderstorm cloud appears to be a very complex mechanism; and our ignorance of the structure and dynamics of clouds is one reason why the hit-or-miss approach to cloud seeding, which caused so much anguish in the 1950's and early 1960's, has failed to live up to expectations.

In the field of atmospheric chemistry, we want to understand the life cycles of trace gases and solids in the atmosphere—carbon dioxide, ozone, etc.—and of the many kinds of particles, technically classed as "aerosols," that float about in the atmosphere—minute drops of resin from evergreen forests, petrochemical solids from auto exhausts, particles from plowed fields, meteor dust from space, etc. NCAR has a large effort in this area, which is really broader than the label of atmospheric chemistry.

We have concentrated effort here not only because it is a largely neglected and underdeveloped field, but also because a critical question lurks here, and it demands a prompt answer. It is possible that man is already modifying his atmosphere significantly, possibly even irreversibly, without even attempting to do so. For example, our burning large amounts of fossil fuel, or our injection of jet airplane exhausts into global air circulation, or the reduction of miles of farmland, prairie, and forest to urban development—these and other acts of man may conceivably be significantly altering our atmospheric environment already, and may even be affecting general weather patterns. We do not know if this is so, but we should find out. If it is so, it is a problem far more grave than the problem of air pollution, in which we also have a great interest and concern.

It is possible that some of the processes involved—such as the injection of carbon dioxide into the atmosphere—may even have century-scale effects on climate. To put it bluntly, we ought to know what we're doing, and the first step toward full understanding is accelerated basic research in the chemistry and physics of atmospheric trace gases and solids—a major aim of this division.

The second laboratory of NCAR is directed by Dr. John W. Firor, a cosmic ray and solar physicist. In the high altitude observatory

we study atmospheres everywhere—in the sun and stars, on other planets, in the space joining the sun and earth. We look at possible extraterrestrial influences on the atmosphere of the earth such as meteor dust, cosmic rays, plasma jets, and the solar wind. There has been, over the past decade or two, much speculation about extraterrestrial influences on the weather, especially in relation to connection between storms on the sun and storms on the earth. In fact, this has been my own personal field of research. This is research of the most basic type, yet it may eventually hold important clues about long-term variations in the earth's climate and the more abrupt changes in week-to-week and month-to-month weather patterns. It may explain things such as the spectacular reversal of climate in 550 B.C., or the change like the one in 1562 which caused a worsening of climate in England. I must say I find it difficult to restrain my enthusiasm in talking about this.

I am especially proud of the high altitude observatory's contribution. The observatory joined in our objectives in 1960, as I did, and we threw all of our resources and interests into NCAR's aims after a 20-year history (the observatory's and mine) of space-oriented solar and solar-terrestrial research.

NCAR's research activities benefit greatly from the participation and criticism of visitors. Over the earlier years of HAO's history we had formal reviews of our research performance by distinguished outside scientists. The UCAR council of members has now taken up the responsibility of formal review, under a plan designed to extend and amplify our earlier procedures. Under the new council plan, one-third of NCAR's future research projection will be reviewed in depth each year, according to a procedure quite similar to the anonymous-reviewer system used so successfully over the years by NSF and others. I have favored this review procedure as a further means of assuring vigorous and independent criticism of NCAR, and yet without courting the dangers of excessive or oppressive bureaucratic control of our operations or our goals.

The advanced study program is headed by Dr. Philip D. Thompson, a mathematician and one of the world's leading experts in numerical weather forecasting. This program has postdoctoral study activities and advanced seminars in looking at what the various roadblocks are in the various fields of research.

The advanced study program is the NCAR effort most closely linked to education. NCAR does not, of course, conduct formal course work, or grant degrees. But we do provide postdoctoral appointments for a limited number of new Ph. D.'s in the atmospheric sciences, astronomy, physics, geology, chemistry, engineering, aerodynamics, mathematics, etc. Under this plan we encourage new scientists to initiate their research careers in a place where they will be exposed to a wide variety of specialties, and where debate flows constantly about which scientific problems are the most important to the progress of the science as a whole. We conduct series of seminars on critical problems for the resident and visiting staff; and UCAR, through private funds, has a fellowship program for pre-Ph. D. graduate students who are free to study in any accredited university of their choice.

Let me turn to the Facilities Division, headed by Dr. Daniel F. Rex, who is one of the scientists who worked under the distinguished Carl

Gustav Rossby, who was an atmospheric science pioneer, and the great creator of two major atmospheric science efforts in the United States.

From the outset of planning of NCAR, the provision of facilities has been one of our prime activities. It is clear that balloons, airplanes, rockets, and computers are essential in atmospheric research; it is equally clear that many of these tools are beyond the reach of the individual university researcher and even beyond the reach of his university.

NCAR now operates three facilities for the joint use of the atmospheric community—in scientific balloon operations, in research aircraft, and in computer usage. We also provide expert consulting service to university experimentalists on experimental techniques, how to get access to existing capabilities elsewhere, etc. In fact, we view this "middleman" function as equally important with the provision of actual physical facilities themselves. Our balloon facility has helped to make advanced and difficult balloon technology readily available to university scientists. This is done through development work on balloon design, launching methods, and communication systems; and through the operation of two balloon flight stations, one in Texas and one in Arizona, where more than 100 flights are launched each year for scientists from more than a score of universities and other research groups.

Our aviation facility now operates two aircraft, and plans to carry out seven experimental projects this summer, four for NCAR staff members and three for outside scientists. The NCAR computing facility is also serving a variety of outside users who require a very high speed computer and experience in its use for atmospheric problems. This is particularly important to some of the smaller institutions that don't have major computer facilities.

Before proposing to the NSF that we undertake establishing any joint-use facility, groups of non-NCAR scientists have made thorough studies to determine whether or not the proposed facility is really needed, and to make recommendations as to how (and possibly by whom) it should be developed. Only when such an outside group has made an urgent recommendation that it should be done at NCAR, and when the NCAR staff studies also show that establishment of the facility is feasible and that no other agency or institution is in an equally good a position to fill the need—only then does NCAR move to create the facility. This kind of caution is essential. Funds for atmospheric research will always be limited, and must be spent wisely and sparingly. In shaping our facilities, we therefore are forever mindful of exactly what needs we should strive to fill.

The next few paragraphs give examples of some of the NCAR facility aid to various universities and how we have organized this, pointing out in some instances we have recommended the creation of facilities which other institutions have carried on, like the University of Hawaii.

For example, in our aviation facility, we have recognized that a university researcher can usually rent a light plane when he needs it. We also recognize that very heavyload, high-performance aircraft are operated for atmospheric research by the Weather Bureau and by the Air Force Cambridge Research Laboratories. NCAR's effort, therefore, is to supply flight time in airplanes that fall between these two

classes. We can thus provide the university researcher a capability he cannot provide for himself, but in aircraft that are smaller and far less costly to operate than the high-performance planes operated by various Government agencies.

With respect to facilities, we have also played a catalytic role. For example, cloud physicists and atmospheric chemists have long looked upon the Island of Hawaii as a near-ideal laboratory for probing the processes of precipitation. As the result of many discussions including several organized under NCAR sponsorship, the Institute of Geophysics of the University of Hawaii is taking the lead in developing such a facility. NCAR is assisting in obtaining, modifying, and installing radars, portable laboratories, power supplies, and communications equipment. But administration, scientific control, and planning responsibility will rest with the University of Hawaii. In short, the university is building and operating a research laboratory of broad national and international significance, and we are helping in this goal. This summer the Hawaii research site is in use by scientists from the United States and from Japan in a program sponsored by NSF and the State Department.

It is assumed, and I think rightly, that the proper site for the heart of the country's basic research is in the universities. This is true in the atmospheric sciences, as elsewhere. In addition, in the atmospheric sciences we have a special need to train a far larger next generation in a field that at times falls down the cracks between conventionally organized departments of a university.

It is also assumed here in America that university scientists can and will wisely do the bulk of the priority setting, at least within a given field of science. NCAR's relationship with the NSF reflects this basic NSF-university philosophy. We in NCAR are, of course, subject to all of the usual difficulties of the Federal budget's cycle. We often wind up with less support in a given fiscal year than I think appropriate for the science to which recent administrations have given such high priority. The problem is acute not only for NCAR, but for the whole of the atmospheric sciences. In time this problem of the need to expand a larger percentage of our total resources will become more serious because NCAR's goal, shared with NSF, is to promote a major advance in this rather neglected broad field of atmospheric science. If we in NCAR and the universities succeed, NSF will have far stronger and far more numerous atmospheric science proposals coming in from the universities.

Because our expenditures under our contract with NSF are subject to various Government restrictions and regulations, we have sometimes encountered snags that have caused serious delays or made it extremely difficult to carry on activities that both NSF and we consider integral to our aims and purposes, and much is in the public interest. NSF has given us solid support in helping overcome these obstacles.

Moreover, the Foundation has exercised its wisdom in this relationship in a much more important way. Both under Dr. Waterman and now under Dr. Haworth, the initiative in scientific planning and in facility development has been left to NCAR, in consultation with the university community. It has been clear from the outset that NCAR is, and should be, a private laboratory operated by a nonprofit corporation representing the scientific community. NSF's leadership

has been constantly vigilant in helping us preserve this principle. The terms of our contract with NSF are extremely broad—

> to organize, operate and maintain a center which will have the following functions of a scientific, interdisciplinary character—to plan and execute basic research programs in collaboration with other scientific and educational institutions * * *; to plan and execute basic research programs of small scale * * *; to develop overall plans for a permanent establishment * * *

(namely, the laboratory that we are now building in Colorado)

> and to carry out such other activities as are recommended from time to time by the Foundation or the contractor and mutually agreed upon by the parties.

This description of our task, it seems to me, is as close to a charter of scientific freedom as one could arrive at within sound governmental practice.

An essential justification for large-scale public support of atmospheric research is the prospect of practical benefit through application—for example, in control of air pollution, in improved long-range weather predictions, in a better understanding of the near-space environment, and in possible modification of weather and climate. Nearly every scientist, of course, wishes to see his research results useful to mankind. Moreover, we are aware that the NSF has been given explicit responsibilities in the field of weather modification.

Our concern with possible applications of knowledge, therefore, arises from both our own scientific interest and from the statutory interest of our partner, the National Science Foundation.

It is, however, characteristic of the atmospheric sciences at this point in time that the line between basic and applied research is impossible to draw. Indeed, there is a significant area of overlap. For example, the problem of constructing a mathematical model of the terrestrial atmosphere, the problem of developing long-range prediction methods, and the problem of realistically assessing various proposed weather modification schemes—all these problems are essentially the same now. But we can see the time not far off when they will begin to diverge, and the question then arises, what should NCAR's role be?

This example of overlapping practical and theoretical problems is particularly relevant because of the imminent development of a global observing network over the next several years.

Dr. Hollomon described briefly, when he was here last week, a most challenging example that has far-reaching potential benefit to the country. In order to make further progress toward understanding the global weather circulation, or to discover how far in advance it is possible to make weather predictions, or to examine the feasibility of various methods of possible weather and climate modification, the network he described must be initiated and operated for an experimental period. We now receive adequate data from only 10 percent of the earth's surface. Ninety percent of the globe is inadequately covered. Satellites, combined with constant-level balloons, ocean buoys, and land stations, offer for the first time a scientifically and economically feasible way of getting the data we need for research progress on the above questions. The experiment will also constitute a very exciting feasibility test of a possible means for an ultimate international weather observing system.

The test will show how much these data can contribute to improving weather prediction using current methods, and more importantly, will spur more rapid development of better prediction methods. They will also contribute to the investigation of a broader question—how predictable the atmosphere really is—that is, how far in advance prediction can ultimately be pushed, and with what accuracy.

Dr. Jule Charney of MIT recently led a National Academy of Sciences study of the potentialities of adequate global observations. In this he foresees a real prospect for 2-week forecasts with an accuracy as good or better than our current 3-day forecasts.

NCAR's interest in the global data concentrates principally on using them for simulation tests of potential weather and climate modification schemes. Before large-scale weather modification schemes are tried in nature, it is essential that global data, taken from the real atmosphere, be used in a computer of adequate size, to discover the full effect of each scheme. For example, we must know whether an effort to relieve a Great Plains drought might not also freeze oranges in Florida. It would be an irresponsible and reckless act to try such schemes in nature without exhaustive prior simulation tests leading to a very high level of assurance of safety, in spite of the potential and extraordinary benefits that would result if the operation could be safely done. Weather modification schemes of this sort, if they work at all, are moreover likely to be realistically computer simulated if global weather data of the type that Dr. Hollomon spoke of become available.

Organizing and setting up the experimental global observing network, is, of course, an enormous administrative and engineering task, requiring complex cooperation on both a national and international scale. Clearly, its management belongs in agencies with existing operational capabilities and responsibilities. It seems to me that the logical agency in this country to manage it is the U.S. Weather Bureau, now in the Environmental Science Service Administration, whose leader Dr. Robert M. White is an outstanding atmospheric scientist. It is not within the current NCAR concept to play the major management or operational role in such a large venture, even though we will soon launch—or hopefully soon launch if some of the difficulties connected with it of an international nature can be cleared up—in cooperation with the Weather Bureau and the Government of New Zealand, about 100 balloons designed to circle the world repeatedly, staying up for 6 months or more, following the natural wind circulation, and transmitting data on winds, temperature, humidity, etc., by means of an extremely light-weight electronics package. I am going to demonstrate it this afternoon, so I brought along the radio transmitter. This fragile device will transmit weather data 3,000 miles to ground stations from a balloon, which is hopefully to fly for 6 months. The radio will be powered by solar energy.

We are also interested in participating in the design of a supercomputer adequate to process the vast amount of data from the global network for large-scale research weather modeling purposes. The computer will have to be about 100 times more powerful than any existing computer. NCAR stands ready to mobilize a team of mathematicians and dynamicists to help write the scientific specifications for such a computer.

51-204—65—vol. 1——33

When the computer is developed, it will be an essential tool in testing global weather modification schemes such as I have mentioned, and it will be our aim in NCAR to own and operate such a computer in order to do so, by numerical simulation, realistic large-scale weather modification, such as jet stream deflection, drought modification, hurricane steering, etc. Such experiments will have great significance also in long-range weather forecasting research—since prediction and modification experiments are part and parcel of the same scientific problem as long-range forecasting. But we do contemplate manning a computer for operational purposes.

We do stand ready, however, to assist in any task connected with the global observing network for which we possess special qualifications. For example, it is likely that certain scientific recommendations may be called for from working groups of university scientists. Because of our close relationship with the universities, NCAR might well be the logical sponsor and host for such groups.

There are other, more modest but still sizable, efforts in atmospheric modification that may yield important practical benefits in years to come—connected with hail suppression, fog dispersal, amelioration of air pollution, modification of the radio reflecting ionosphere, artificial aurora production, etc.

In such areas, NCAR's role will be concerned with the linkage between the new knowledge now being produced and its wise and prompt application. Our role will be both analytic and catalytic. We will examine progress being made toward applications; help assess the potential value of such applications; define major scientific and technical roadblocks and knowledge gaps; and assist in planning specific attacks aimed at clearing the obstacles away.

In seeking to plan ways to couple basic research results to practical use, we in NCAR will call not only on our own staff, but on atmospheric scientists from the universities and elsewhere to join us in special studies lasting from several months to over 2 years, each study devoted to a specific problem for which we have staff interest and competence. If it should develop from such analyses from time to time that NCAR is the most logical group to carry forward a major experimental program—for example, in the investigation of hail suppression methods—we will do so, but only if we have full endorsement and cooperation of the agencies who will ultimately be responsible for the application.

By organizing and limiting our effort in this way, it is our expectation that we can avoid losing the essential focus of basic research we have now attained, and still make a unique contribution toward the achievement of wise and effective applications. And this mode of activity, I believe, will put us in highly effective partnership with the scientific community and with various interested Government agencies.

In conclusion, Mr. Chairman, I would only say that from my view the Foundation's leadership and support of our effort have been bold and effective. The partnership I have described has been more successful than we dared hope at the outset 5 years ago. Five years ago I felt that hope was shining enough to be willing to change my entire field of scientific research from astronomy to atmospheric sciences, and the rewards have been enormous—the association with the highly

competent staff of the Foundation in atmospheric sciences and the support and enthusiasm of both Dr. Waterman and Dr. Haworth. It has been an evolving partnership, not without problems and obstacles; but it has, I believe, proven its soundness and usefulness to the society and the scientific community it serves. I believe that a study of the other two NSF-sponsored national laboratories would reveal a similarly effective accommodation to the needs of the American pattern for building a stronger science for public good.

Thank you, sir.

Mr. DADDARIO. Thank you, Dr. Roberts. Mr. Davis.

Mr. DAVIS. I recall 2 or 3 years ago Dr. Edward Teller showed a film to our committee. It was a display of a week's worth of weather. As I recall it, it showed the movement of isobars around the earth's surface. Was that effort in any way coordinated with NCAR? Where was he working from? I don't recall.

Dr. ROBERTS. That film that you speak of, sir, was I believe prepared by Dr. Cecil Leith, of the University of California, at the Livermore Laboratories and was one of the first applications of a major computer to the preparation of an actual moving picture map of weather systems. It was very striking in the reality that it showed, even though the model was enormously simplified. That was done before NCAR had a major research capability in this area, but Dr. Leith is now chairman of the computer advisory committee of NCAR and is the man principally taking the lead in advising and helping NCAR to develop computer capabilities to extend this sort of study to a far more realistic model. Leith's model, in spite of its fascinating similarities, to real weather, had many features that were unrealistically simple. But it showed such promise that we believed it could be done realistically if we have the resources.

Mr. DAVIS. I recall they did not program the Rocky Mountains into that.

Dr. ROBERTS. That is correct, sir. The Rocky Mountains, of course, have an enormous influence on the weather all over the world. They stabilize a position in the average trough systems so that the Rocky Mountains influence the weather not only of the United States but the weather of England and the weather of the whole Northern Hemisphere. We are quite proud of those Rocky Mountains of Colorado!

Mr. DAVIS. I don't blame you a bit. What incentives are there for a university to become a member of NCAR and what expense would be entailed?

Dr. ROBERTS. We feel that the principal incentive to a university is an opportunity to participate in the planning, guidance and management of something designed to change the whole science in the public interest. A university, to become a member, has to agree to provide a scientist, or two scientists and an administrator if it is one of founding members of NCAR. The original 14 founding institutions had to make contributions of cash, and I regret to say I forget the exact amount. (Added later: $2,500 was required of founding members.) The new institutions brought in now have to make a nominal contribution of cash (added later: $1,000) as a token of membership. They also have to meet certain criteria, certain standards in respect to the offering of graduate courses of instruction and research leading to the doctorate in atmospheric sciences or a closely related field.

Mr. DAVIS. You said they have to provide a scientist. Does that mean they have to provide a person to reside at NCAR?

Dr. ROBERTS. No, sir. They must name a representative to serve on the Council, and if they are one of the original founding institutions, they must in addition name two trustees, one an administrator and one a scientist. The Board of Trustees handles management, fiscal and budgetary policy, and the Council of members handles scientific guidance, evaluation and so on. The institutions designate a person to serve on this Board when required, and many of these men, like Dr. Robert Fleagle, of the University of Washington in Seattle, will spend probably 20 days over the coming year, maybe even longer, evaluating the performance of NCAR, seeking reviews of its competence, developing constructive criticism and so on.

Mr. DAVIS. Do you consult or are you in communication with such agencies as the FAA as to what their requirements are? What they would really like to know, for example, about thunderstorm activity and things of that kind, and where they need help? Do you communicate with agencies like that?

Dr. ROBERTS. Yes, sir. We are in quite close touch with agencies, many agencies. Nearly every agency has some involvement in weather science, and we are in touch as widely as possible, where we feel that one of the new discoveries or one of the areas of promise in basic research may have an ultimate or even a short-term application to the interests of the particular agency. Our scientists have a sort of responsibility as a member of a national laboratory to make themselves available for advice to government, to industry, to the universities, to anyone, that has a legitimate and proper scientific need for this information, to consult about where application might be made. I might say that the scientists regard this responsibility as a very important and serious one.

Mr. DAVIS. Dr. Hollomon the other day made an observation to the effect that the people who generally—I am not sure I am going to quote him exactly right—generated and funded the research, are usually favored with the fruits of research. With that particular thought in mind, what has generated the interest in NCAR in these universities which you show on the map? Can you put your finger on agriculture or any particular thing?

Dr. ROBERTS. No.

Mr. DAVIS. Is it just an esoteric interest in meteorology?

Dr. ROBERTS. The basic interest which led to the creation of NCAR and the participation by the universities was the realization that the atmospheric sciences had not kept pace with the progress of chemistry, physics, and other areas of science in spite of the development of relevant tools. So it was essentially realizing that the short-term demands for application should not be allowed to stand in the way of bringing this science to the most modern peak of excellence and contribution as a basic research activity.

Mr. DAVIS. Is the interest one that stems from simply intellectual curiosity or is there a practical need? For example, the depression brought on a need to study economics. I notice the distribution here doesn't seem to follow any particular pattern. Would you say it is simply an intellectual realization of the truth?

Dr. ROBERTS. Yes, sir, I think so. It was a realization that this science generally has an enormous contribution to make to the welfare of the country, and that the universities should, as a matter of responsibility, join in bringing it up to a modern state of excellence. This, in fact, was the essence of the National Academy of Science's report, that third recommendation I referred to earlier. The recommendation was that without the creation of a major basic research center like this, the science would continue to lag, partly because of the extraordinary demands that were made for the training of relatively nonscientific weather observers for the weather service. This generally in university structures led the Department of Meteorology to be looked down upon by bright young mathematically and physically oriented students who were considering a scientific career, because "over there" is where you drew isobars and weather maps and wet your finger and held it up in the air; and that wasn't for them. It was felt necessary that to make more evident the real challenge, for this scientific problem is one of the most difficult scientific problems ever undertaken by men. It was felt necessary for it to have a chance to contest with physics and chemistry and other "nonessential" sciences—excuse me, I shouldn't have said that—to contest with the other sciences for the talent of the most outstanding youngsters. That is the heart of the problem. We need to get the first rate youngsters to be interested in the atmospheric sciences, not those that just can't take math. The math and the engineering that are involved in the atmospheric sciences are among the toughest problems. The problems are equal to the toughest in nuclear physics or molecular biology. I personally believe the potential benefits to our society are equal to nuclear physics or molecular biology.

Mr. DAVIS. I notice in the paper this morning that the Weather Bureau is a nonprofit organization. The hooker was they spelled it p-r-o-p-h-e-t.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Do we have your budget figures over the last few years? I assume we do.

Dr. ROBERTS. If you don't, we can provide it.

Mr. CONABLE. Do you have any budgetary comments?

Dr. ROBERTS. No, except the Foundation has been giving us very excellent support. We have had long and detailed discussions of the objectives and the needs, and they have given us solid and effective support in achieving the objective.

Mr. CONABLE. Has your budget risen faster than the overall budget of the Foundation percentagewise?

Dr. ROBERTS. It is certain to have, sir, because we had no budget before 1960. But it has risen quite abruptly.

Mr. CONABLE. In the last 2 or 3 years?

Dr. ROBERTS. Yes. It was considered a necessary objective because of the particular requirements of atmospheric science that a major laboratory be created as rapidly as it could be created.

Mr. CONABLE. And you expect that will continue until you reach the maturity that you say is now only two-thirds in all probability?

Dr. ROBERTS. Yes, sir. Although the curve of funding and the curve of staffing has already begun to level off toward the objective which I very firmly hold in mind of a limitation of growth at a size of about

600 scientists as compared to about the 380 or 400 that we now have. After that the growth will be "sub-Parkinsonian."

Mr. DADDARIO. Mr. Conable refers to the fact that you have budget problems on occasion. I imagine this is one of the things that goes with this charter of scientific freedom that you have arrived at.

Dr. ROBERTS. Yes, sir.

Mr. DADDARIO. You wrestle with that as the rest of us do. Do you have some thoughts about the development of such an organization as yours, of others of its size and rigidity, and then the maintenance of continuity are a part of the National Science Foundation, current and future function? How do you look at that as being a proper function within the National Science Foundation? What effect might it have on the other work which the National Science Foundation might have to do? Father Hesburgh touched on the fact that certain of these inflexible parts restrict the opportunity to do more things in other areas. Now does this fit in, in your view, Dr. Roberts?

Dr. ROBERTS. Of course, I have never been privileged to be a member of the National Science Board or to sit in on their deliberations, but from where I sit the case of a science that is severely underdeveloped compared to its potential contribution, it seems to me, following again the National Academy of Science's argument, it seems to me there is no other way than to create major facilities or major research capabilities aimed at basic research, not aimed at a particular mission orientation. You see, in the atmospheric sciences particularly, the short term demands of the particular mission—orientation of the agency, like the Weather Bureau, for example, make it difficult for research to grow in an appropriate pattern. I think it is a fairly established thing that in the Weather Bureau basic research did not prosper as the potentialities represented by physics, mathematics, computer science, etc., made potentially possible. It was the conclusion that an activity closely related to basic research in the university community was necessary. That being so, that the National Science Foundation was the logical and proper agency under which for this to develop. I think the crux of the matter of whether it is proper and going to be effective in the long run, the crux of the matter depends on whether the institution, NCAR (or the other national laboratories), continue to serve the basic research needs and continue to benefit the universities of the country generally. If, for example, NCAR should get its eye principally on doing research in the fastest and most effective way and not on the growth of the university community and the atmospheric sciences in general, than I think there would be some hazard in the NSF funding of the laboratory, but I can assure you as long as I am Director of NCAR it will exist to serve the universities and progress in basic science.

Mr. DADDARIO. The guidelines you spell out involve the development of programs in basic areas with a great requirement being on the need and the effect it will have on the Nation and the fact that we can fund that and still do the other things which must be done?

Dr. ROBERTS. Yes, sir.

Mr. DADDARIO. This would mean then that there should be serious and important debate on each of these programs so that the Congress would recognize that this is being done, therefore, they cannot pick

that up, and support the rest of the program in a proper percentage relationship to what needs to be done?

Dr. ROBERTS. Yes, sir, precisely. As a matter of fact, if NCAR were looked upon as an alternative to the support of atmospheric science through the grants programs in the universities and so on, NCAR would not be serving its objective, and it would then be inappropriate to continue the support of NCAR in the National Science Foundation.

Mr. DADDARIO. This was what you were referring to, then, Father Hesburgh?

Father HESBURGH. Exactly.

Mr. DADDARIO. We have got to be careful how we maintain the balance within the development of the National Science Foundation, recognizing the need which Dr. Roberts has brought out in such areas as this.

Father HESBURGH. That is right.

Dr. ROBERTS. The entire budget and the entire planning of NCAR must run the hurdle of UCAR Council scrutiny, it must then come to the UCAR Board of Trustees, and it must be adopted by the Board of Trustees as representing the consensus of these people as to what NCAR should be, so that in a sense as university members they are looking at the benefit to their own activity, and I reiterate repeatedly to them that in my view they must see this as a benefit to the growth of the university work in atmospheric sciences.

Mr. DADDARIO. Do you have a question, Mr. Yeager?

Mr. YEAGER. Perhaps I had better submit this for the record.[1]

Mr. DADDARIO. I want to thank you, Dr. Roberts and Father Hesburgh for having made this such an informative morning. The help you gave us I am sure will reflect itself as we continue these hearings. We will be in touch with both of you so far as additional queries are concerned.

This committee will adjourn until tomorrow morning at 10 o'clock at the same place.

(Whereupon, at 12:30 p.m., the subcommittee was adjourned to reconvene at 10 a.m., Thursday, July 22, 1965.)

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

THURSDAY, JULY 22, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. This meeting will come to order.

Our first witness this morning is Dr. S. Dillon Ripley, who is the distinguished Secretary of the Smithsonian Institution. He is well known to us on this committee, both in his present capacity and as the past Director of Yale's Peabody Museum of Natural History for a long period of time. We are happy to have you here Dr. Ripley.

STATEMENT OF DR. S. DILLON RIPLEY, SECRETARY, SMITHSONIAN INSTITUTION

Dr. Ripley. Thank you very much, Mr. Chairman. I am delighted to be here today to address the Subcommittee on Science, Research, and Development. I want to say what a pleasure it is for me as Secretary of the Smithsonian to have been asked to come and testify and to discuss the National Science Foundation from the standpoint of the Smithsonian.

I should like to begin with some comments on the similarities and differences between the Smithsonian and the NSF, discuss the present situation of the NSF with reference to the position of basic research in the Nation, and conclude with a brief discussion of the Science Information Exchange, one of our principal common enterprises.

I. THE SMITHSONIAN AND THE NSF—SIMILARITIES AND DIFFERENCES

The Smithsonian Institution was constituted as an independent establishment under the Government of the United States "for the increase and diffusion of knowledge among men." Prof. Joseph Henry, the first Secretary, strove ardently to address the Institution's efforts to the improvement of basic research, especially experimental science, at a time when there were no laboratories in the United States devoted to such investigations. While the original Smithson bequest seemed magnificent to most, Henry was keenly aware that it was a limited sum that would soon disappear or lose its forces if the Smithsonian assumed the burden of major national programs.

Rather than become a service organization for others, like a library or mere repository of objects, or a college to offer instruction in what was already known, it was Henry's view that the Smithsonian should be devoted to the acquisition of new knowledge and its dissemination to learned societies and academies throughout the world. Through its laboratories and lecture halls the Smithsonian became a forerunner of the modern graduate university. It was dedicated to the improvement of basic research in America by helping to establish unfamiliar fields of study, maintaining groups of investigators in especially worthwhile areas and championing the idea of the disinterested pursuit of knowledge for its own sake.

The National Science Foundation, also established to improve the situation of basic research, reflected the thinking of Vannevar Bush's famous study, "Science—the Endless Frontier," which focuses concern on the overall level of effort in basic research in the Nation as a whole, urging that:

> The Government should accept new responsibilities for promoting the flow of new scientific knowledge and the development of scientific talent in our youth.

The Smithsonian still retains a general concern for the situation of basic research. That responsibility is met through activities undertaken directly by the Institution, not by making financial support generally available to the scientific community.

If the Smithsonian enjoyed a brief monopoly as the principal basic research organization in the United States that position has been cheerfully foregone as our great national complex of research organizations came into being. Where needs have existed for an organization to perform specific tasks in research the Smithsonian has often responded. But its focus is upon pinpointed requirements rather than generalized levels of support.

For example, when it became apparent that large-scale flood control projects in the American West would jeopardize important archeological sites the Smithsonian organized a national program of salvage archeology as a joint project with the Department of the Interior. Prior to the International Geophysical Year astronomers recognized the need for a system of visual satellite tracking stations, now operated in 10 countries by the Smithsonian Astrophysical Observatory. For many years the Institution's Radiation Biology Laboratory has undertaken to compute the solar constant and calibrate measuring devices for solar radiation. The National Zoological Park was the first zoo to be devoted to the preservation and breeding of rare and endangered species, a lively concern today which dates back to Secretary Baird, who tethered bison on the Mall and saw to it that a breeding herd was kept. The Smithsonian Oceanographic Sorting Center has been created to refer specimens collected in the national marine biology program to appropriate specialists all over the world for analysis and identification. These are but a few examples of specific Smithsonian responses to national needs in basic research.

The National Science Foundation is concerned with all fields of science, while the Smithsonian has restricted its activities to a range of rather specific disciplines. In the sciences these are astrophysics and earth sciences, anthropology, marine biology, systematic biology, and environmental biology. Among the humanities these are his-

tory, fine arts, and portraiture, with special reference to American studies. In addition, the Smithsonian has given prominence to the operation of museums, galleries, and other forms of exhibition for the enlightenment of the public. Thus a number of its programs in scientific research and scholarship are oriented toward support for the museum activities of the Institution. It might be said that the research efforts of the Smithsonian come to a focus in three central, classical concerns of science; the nature of the universe, the organization of life, and the nature and history of man's culture.

While the Smithsonian's tradition is that of the direct performance of research, it has not been limited to in-house activities. It formerly awarded premiums for distinguished research and has always been one of America's foremost scientific publishing houses. The predecessors of today's Environmental Science Services Administration, Fish and Wildlife Service, and NASA all began as Smithsonian activities that were spun off, as it were, into independence as their scientific potential justified the development of mission-oriented Government agencies. While the Institution might be said to provide extramural support on occasion, this is usually where the investigator's activity is directly related to projects underway within the Institution. Such support may involve specific contracts for the performance of services or loans of specimens from the national collections. Those who perform the work might be said to be agents, rather than beneficiaries, of the Institution, which itself benefits from having the work carried out.

Today there is increasing interest in extramural activities, from research contracts to fellowships, in tropical biology, the museum professions, anthropology, fine arts, and marine biology. The Institution has recently begun a program of grants of excess currencies with reference to museum programs and associated research in archeology, the natural sciences, and cultural history.

The Smithsonian has on numerous occasions received NSF support. One category of grants has been for research projects of individual Smithsonian staff members. So long as the prohibition against transfers of NSF funds for research in agencies receiving appropriated funds continues in force, the Smithsonian will not receive NSF grants for this purpose. It is contemplated, however, that grants and contracts for educational services, information services, and participation in national programs funded by the NSF will continue. At the present time these include funds for visiting research appointments for undergraduate science students, the support of the Science Information Exchange, and a number of projects in oceanography and Antarctic research. I may add that the endorsement of Smithsonian activities by NSF panels, the service of Smithsonian staff members in reviewing proposals, and our mutual participation in considering national research needs has resulted in a highly gratifying partnership between the Smithsonian and the NSF in a host of instances. We have greatly enjoyed and profited from these associations.

In the last analysis, the level of support and range of activities of the Smithsonian reflects opportunities for significant research. The level of support for the NSF reflects, or should reflect, the situation of science in the Nation. It might be said that the Smithsonian is able to concentrate on its own institutional objectives where the NSF or other supporting agencies have met national needs adequately.

II. THE NSF AND NATIONAL NEEDS IN BASIC RESEARCH

It was my privilege to have one of the first National Science Foundation grants, for the study of the birds of continental and southeast Asia. My direct experience of NSF granting programs has continued in a number of museums and universities. The Foundation has never taken a narrow view of its charter. Grants have been made available to investigators in different kinds of institutions: to scientific societies, publication projects, and other categories. The Foundation has had remarkable leadership and a distinguished staff. It has responded courageously to the demands of scientific freedom in the terms of support and projects chosen. It has helped to promote a truly astonishing civic spirit in science whereby the members of the scientific community give generously of their time and advice through a consultant and panel system that I believe to be unique in the annals of Government. It has demonstrated its fitness for its mission of promoting the development of basic research in the national interest. I recommend that this subcommittee consider means of enabling the Foundation to respond more effectively to the situation of basic research in our society.

As Dr. Haworth pointed out earlier in these hearings, the NSF is unable to support all projects deemed worthy of support. And the average successful project is reduced in dollar amount or in term of years when a grant is made. Not until the Foundation comes abreast of the financial needs of basic research will it be properly situated to fulfill its function. The Foundation must be placed in the position of being able to assess national need and propose remedies. At present it must struggle to adapt too little money to a hopelessly broad series of objectives. We have substituted an artificial financial level for the national standard that the NSF was constituted to maintain. In my view the Foundation has not yet been able to operate as it should, which would be by translating the Nation's needs for basic research into programs of Government support. The first imperative is a rapid and decisive phase of growth well beyond its present dollar level. Other witnesses have used the figure of $1 billion. I agree with them. I wish to underscore this recommendation in three ways:

First, much has been said, in the National Academy report and in testimony, about adopting a basic research growth rate of 15 percent per year. That figure is based upon two factors, needed growth in graduate education at a rate of 8 to 10 percent per year, and increased costs in research of 5 to 7 percent per year. I agree with the 15 percent figure and believe its adoption would be desirable. But the present Foundation budget is too small to be a sufficient base upon which the addition of 15 percent each year would accomplish the Foundation's overall objectives.

Second, we must not rely on applied research agencies or applied research tasks to yield of themselves an adequate return in basic knowledge. As Alvin Weinberg has told the subcommittee, the missions of the DOD, AEC, and NASA are not going to expand as rapidly as the needs for basic research and these agencies must not be relied upon to provide the funds we need. My attention was recently drawn to a statement by Goldsmith and Mackay in the introduction to their collection of essays. "The Science of Science," Souvenir Press, 1964.

They argue that "a general problem of social importance provides as good a beach for combing for the unplanned discovery as does complete freedom." Of course, this occasionally happens but there is no evidence to warrant a general conclusion that we should emphasize applied research and leave basic research to shift for itself. It would be a solecism in research policy to expect applied research to yield a sufficient return of basic knowledge.

Mr. DADDARIO. Dr. Ripley, in this regard, how do you see the function of such mission-oriented agencies in providing a certain level of basic research both for national purposes, and also to accomplish its own mission-oriented objectives? We have had some discussion of this, and I would like your opinion. Are you suggesting that the mission-oriented agencies should devote themselves only to applied research and have no basic function, and that this basic research function should be either controlled or performed by NSF?

Dr. RIPLEY. I think it is very hard to set up a kind of formula, mathematical formula, but my impression is, Mr. Chairman, that the experience of the past in science has shown that certain applied laboratories do produce—I used the word spin off earlier— spin off basic results, and I think it is almost impossible to assess how this process is going to come because it is essentially an intellectual process. If you have laboratories in operation with scientists who have essentially applied missions, they are bound to spin off and generate ideas which have basic value. You can't prevent it. On the other hand, I don't think you can estimate exactly what the proportion is going to be.

It is almost impossible to analyze. This is probably an unsatisfactory answer, but I have never been able to determine exactly what proportion of persons working in a laboratory with a mission can prevent themselves, as it were, from having ideas which are peripheral to the central mission, but which may be of a basic nature.

Mr. DADDARIO. The theory has been proposed during these hearings that the mission-oriented agencies need to perform basic research in order to help them achieve their objectives. Perhaps the corollary of that is also true, that in order to help give drive to its basic research, NSF ought to have an applied research responsibility. The question then if this happens, would NSF get into an area of activity within which there are so many inflexible elements that it could not maintain enough flexibility to perform its basic research function? I would like your view on that.

Dr. RIPLEY. My own premise would be that in regard to the basic research oriented laboratories or agencies, they should confine themselves essentially to basic research. It is very difficult to analyze a corollary series of applied missions. This is an area where we may find that in terms of environmental biology and environmental health there may be considerable overlap almost of necessity, and in this area I would be willing to hedge about the kinds of applied missions that I would see basic oriented agencies undertake.

Mr. DADDARIO. Could you go into that a little bit?

Dr. RIPLEY. Well, I am very much interested myself in terms of being a conservationist in the corollary problems of environmental biology which involve pollution and use of pesticides and activities of this sort. Instantly when one gets into analyses of these which may be basically directed one tends to find oneself—perhaps coordinating

would be a better word rather than overlapping—coordinating with a number of other activities which may be of an applied nature. That is what I mean.

Mr. DADDARIO. Fine, thank you.

Dr. RIPLEY. It is sometimes said that we have an unused surplus of knowledge that has resulted from basic research—that there are more good scientific ideas on hand than can be followed up for purposes of applied R. & D. I think this is quite incorrect. Even in applied research fields themselves, although I am not an expert in technology, it appears that many processes and devices are unnecessarily primitive for lack of the necessary scientific understanding. If this were not the case, why would applied research agencies such as the DOD or private industry have to support some basic research in related fields?

Even more important, Mr. Chairman, is the fact that man's knowledge supports abundant intuitions of new areas of investigation that cannot be properly followed up, for lack of trained investigators and lack of funds. We are not progressing sufficiently rapidly in our investigations of life processes, chemistry, human psychology, and physical processes at all levels. At the Smithsonian I feel every day the enormous urgency of such matters as the need to study species and environments that may disappear before man has indeed learned their secrets, or cultures that will disappear before they are understood or even placed on record.

In a very real sense the process of setting a proper level for the National Science Foundation requires us to answer the question, "How much science?"

This subcommittee has contributed a great deal to public discussion of this question. It is one that the Smithsonian Institution was created to engage. The starting point for my answer is not the digestive capacity of science-oriented industry, or the needs of graduate education. It is the situation of knowledge. Dr. Johnson said we would all rather know a fact than not know it. Well, I would not be quite so matter of fact. We cannot, for example, insist that the developing nations cease to clear their jungles until we have learned the precise location of all the undescribed species of snails. Science must not be permitted to claim an overlarge share of public resources. So there is a need for balancing competing claims and a wide public discussion of how to strike that balance has already begun.

We welcome the public discussion of our national policy for science, believing that a positive desire for new knowledge must be widely shared among the people before it can be secure among the aims of government. This Institution has been a champion of basic research since its foundation, but its responsibility is not to ask for more just because this is a built-in-institutional precept. We would be responsible for saying we have done enough if that were indeed the case. I am here today to state that we have not done enough.

We spend $10 per inhabitant per year in the United States on basic research. We spend perhaps 10 times as much on all research and development. We might think of all R. & D. as involving cigarette money; basic research costs the average citizen about as much as his chewing gum. If you all insist on chewing gum. These are homely comparisons. I have heard it said that all spending for basic research since the beginning of science equals the value added by the

world's industrial establishment to it raw materials in each 5-day period. Surely we are not saying that we have begun to approach the limits of our ability to finance basic research, when such investments are minor in themselves and almost inevitably repay us many times over. The limits have always been too few laboratories, too few teachers to produce new scientists, and too few opportunities for our people to receive training. Indeed the NSF has been charged with expanding just exactly these opportunities.

In a democracy the limit upon pure science should not be what the government chooses to spend, but the public's appetite to know. Where more young men and women would elect scientific careers than have the opportunity to pursue their inclination, we have too little science. Where the Nation's community of scientists wish to pursue their chosen investigations, and these are found to have merit, it is lamentable that public authorities should deny them the opportunity. The National Science Foundation Act authorized and directs the Foundation to—

initiate and support basic scientific research and programs to strengthen scientific research potential in the mathematical, physical, medical, biological, engineering, and other sciences.

The act and the reports that preceded its adoption are instinct with the notion that the Foundation would devote its efforts to discovering a proper level of support for basic research. In a very real sense, Mr. Chairman, the Foundation does not operate by answering that question. It does its best—and it is a very good job indeed—with the resources at its disposal. But the level of resources available has not reflected the situation of basic research in our society—only the ability of one agency among several to secure funds. I find this a cruel paradox and an altogether inadequate response on the part of our society to opportunities for the very best kind of public investment we have yet learned how to make.

I wish to comment on another aspect of the Foundation's present situation, and I do so because this has greatly affected the tradition and history of the Smithsonian. The need for funds is matched by a need to maintain administrative flexibility in dispensing them. The Foundation should never be locked in to a few specified categories of activity, a geographical formula, or devices for support that constrain the investigator.

The choice of the word "Foundation" for the NSF presumably reflected a conviction on the part of Congress and its advisers to maintain the utmost in flexibility, just as in the world of the great private foundations. I believe that the Foundation should be trusted to devise its own formulas for cost sharing and overhead, to choose its own management procedures, and to arrive at its own determinations about areas for support.

There is no surer way to devalue the Federal research dollar than to tie it to unwise or unduly rigid administrative requirements. The scientific literature is nowadays replete with expressions of concern on this score. If we are wise we will entrust the Foundation with maximum administrative latitude. It is easy to buy effort in research; it is far more difficult to provide for scientific results.

For 119 years the Smithsonian Institution has been centrally involved in our Nation's scientific and cultural life. Throughout this

time it has been guided by the wise advice of the scientific community and by the powerful traditions of science itself. I find in observing the National Science Foundation and in becoming acquainted with its staff the same traditions of quality and freedom, the same integrity of judgment, and the same dependence upon advice widely and freely given. To the extent I am able to judge the Foundation has made provision for a distinguished future. It seems sure to prove adequate to the challenge of the endless frontier. I believe that the time is at hand to provide secure guarantees of its national status as the principal agency of the Government for the support of basic research, and guarantees of the freedom and financial wherewithal that will permit it to discharge that mission.

III. THE SCIENCE INFORMATION EXCHANGE

I would like to speak, Mr. Chairman, for a moment about what we call the SIE, the Science Information Exchange. Fifteen years ago, foresighted research administrators of several Federal agencies agreed to pool information about their planned and on-going research activities, and to provide the funds to carry this out. This step was taken in 1949 in the interest of better research management in the face of rapidly rising research expenditure. Subsequent events have fully justified their anticipation and action.

Under the aegis of the Smithsonian Institution since 1953, a research information exchange system, known first as the Medical Science Information Exchange (MSIE), then as the Bio-Sciences Information Exchange (BSIE) and, since 1961, the Science Information Exchange (SIE), grew rapidly from a small collection of a few thousand records of currently active research tasks to the present office with a staff of 160 people and annual expenses of about $1½ million. In fiscal year 1965, SIE collected over 100,000 records of research proposals and active tasks and answered about 43,000 questions for all echelons of the scientific research community. The interest and requests for service continue to grow.

The unique feature of this pioneer venture has been its comprehensive store of information about research in its planning and progress phases long before it becomes accessible through the libraries, documentation centers, and technical journals that report only the completed results, often 1 to 3 years after the work actually started. The Exchange thus offers its users information about who is working on what specific research projects or problems, where, when, and with what level of effort. SIE now covers all fields of basic and applied research in the life, social, and physical sciences. Needless to say this information becomes an ever more valuable national archive of research. The highest priority should be given to its continued development.

While the highest priority for both the acquisition of records and provision of services is placed upon federally supported projects, the 1965 total of 70,000 currently active tasks included a substantial number voluntarily registered by some 200 private research organizations.

There are many ways in which this store of research information can be used, but the most immediate benefit to the Government is in avoiding duplication of support for a given project by learning from SIE whether it or a similar undertaking is already receiving support.

President Johnson's recent report on economy, war on waste, singled out the SIE for praise, saying:

> A busy scientist wishing to know what's going on currently in Federal research on the kinetics of conversion of anhydrous boron oxide to boron nitride can turn to the SIE for an up-to-date answer in detail—who is currently working on the problem, where, and with whose financial support. It can offer the same answering service for research that is being proposed or actually in progress in any science from astronomy to zoology. This clearinghouse on research project information conserves time, funds, and scarce scientific manpower.

The information is stored in the IBM 1460 computer on a unit basis (the "Notice of Research Project" form) and answers to widely varying types of inquiries may be selected and assembled. Questions range all the way from the inquiry of a single scientist about a single subject of investigation to the recent Presidential request to prepare the Water Resources Research Catalog, a 415-page indexed collection of over 1,400 Federal research projects in the general field of water resources research.

Over the years this service has grown steadily with considerable evidence of the users' acceptance and satisfaction. One of the principal conclusions of the Elliott committee was:

> The continued Federal support of SIE is deemed to be warranted. Its services, both to the scientific community at large and to research administrators, are clearly useful; as a tool for coordination and avoidance of needless duplication, it has already paid for itself many times over.[1]

Hundreds of letters from scientists and engineers in Government, universities, and industry have indicated their satisfaction, and of 500 users actually queried, 95 percent stated that they learned for the first time about new investigations or investigators in their own specialties through SIE.

For the first 14 years, the Exchange was governed by Federal agencies under a mutual agreement to share their research information and the costs of obtaining it. Authority and policy guidance resided in a Board of Governors whose members represented the participating agencies. When the annual cost of the Exchange rose over a million dollars annually, the interagency funding situation was judged inadequate and in 1963, the National Science Foundation was asked to provide the entire support on behalf of all the agencies and directed to continue the use of the Smithsonian Institution as the operating agency. The former operating board is now advisory to the NSF, which sets policy, scope, and procedures under a charter of agreement with the Smithsonian.

In a government whose operations must sometimes proceed according to regulations essentially unsuited to their purposes, the SIE is a noteworthy example of a self-reinforcing system that works almost automatically. As individual scientists and program directors in supporting organizations find SIE services helpful, they become more willing to provide the desired input of information about their own activities. This builds up a kind of mutualism, as it were, between the agencies providing the information and the scientists reporting to them, who become more willing to provide information once they find that the service works.

[1] U.S. House of Representatives, 88th Cong., 2d sess., committee print, Select Committee on Government Research, study No. I, "Administration of Research and Development Grants," p. 90.

The greater the volume of input, the more nearly complete the SIE answering service becomes in its coverage of any subject. Some Federal agencies have experienced difficulty in adapting their research project information systems to SIE requirements. The Committee on Scientific and Technical Information, of the Federal Council for Science and Technology, has been cognizant of this situation and is, I understand, taking steps to urge all agencies supporting research to report fully and on a current basis to the SIE.

I am committed to the continued development of the SIE, not only as a matter of sound Government operation, but because it promises to fill a gap that may become an ever more serious problem for science. As the volume of literature grows and it becomes less and less possible for scientists attending conferences to hear in person the papers of their colleagues, the scientist will be in danger of losing communication with his colleagues through simple ignorance of who they are or what they are doing. Already this problem has led some investigators, especially those in the foremost rank of workers on theoretical problems, to maintain mailing lists of colleagues in order to exchange mimeographed previews of forthcoming papers. These little "invisible colleges—usually small groups of specialists in advanced fields—usually include investigators of established reputation, but not the unrecognized scholar, or the man in a related discipline whose work has only recently become pertinent to the members of the actively communicating group.

In my own field of ecology, a man may actively work on a given problem for some years before a publication results; the old system of learning about such work from colleagues breaks down as the lines of communication become ever longer, involving the entire world and hundreds rather than dozens of fellow investigators. I find time after time if I write a paper on an ecological problem myself that three or four of my best friends and colleagues don't know I have written it, and I have to remind them anywhere, in a drug store or a scientific meeting, "Have you got that paper and why haven't I seen yours that somebody else told me about? This happens all the time. A "current awareness" information scheme such as that of the SIE is likely to be of the utmost value in maintaining the traditional open community aspect of science.

In concluding, Mr. Chairman, let me return to a question raised earlier. Is there too much science? Let me say at the outset that the Smithsonian and other museums and related institutions have a great responsibility to help educate members of the public to appreciate the vast scope of man's knowledge. This theme—man's knowledge—has, for example, been chosen as the theme of this year's celebration at the Smithsonian of the bicentennial of the birth of the Institution's founder, James Smithson, whose famous bequest led to the establishment of the Smithsonian. We ardently hope that the 14 million visitors to our buildings, and the 200 million who visit the museums of the Nation each year, grow in their understanding of our present age of science. Much more is to be done, with new exhibits techniques and the development of radio and educational television. We should resolve that knowledge shall be advanced but not beyond the reach of the citizen.

Ultimately, I believe that the advances of science will be for the citizen what they have been for the scientific community, one of the most remarkable achievements of our civilization and a redeeming feature of man's still brief tenure of the planet. To preserve himself and meet the challenges of constant change, man's knowledge must grow at an ever-increasing rate. I feel that I must answer my own question by saying that there can probably never be enough science, and that our need for the National Science Foundation will be a mounting and continuing one. I respectfully suggest that this subcommittee consider what man would lose in stature if his questions ever were entirely answered, if he ceased his quest for new knowledge, or lost faith in his ability to capture it from the unknown.

I should like to conclude by showing that a great deal of this is current, but a great deal of it has always been current in our Nation. I am quoting from the eighth annual report of the Smithsonian in 1853 and the words of Prof. Joseph Henry, the physicist who became its first Secretary. He said:

> There is another division with regard to knowledge which Smithson does not embrace in his design, viz: the application of knowledge to useful purposes in the arts: and it was not necessary he should found an institution for this purpose. There are already in every civilized country establishments and patent laws for the encouragement of this department of mental industry. As soon as any branch of science can be brought to bear on the necessities, conveniences, or luxuries of life, it meets with encouragement and reward. Not so with the discovery of the incipient principles of science. The investigations which lead to these receive no fostering care from government, and are considered by the superficial observer as trifles unworthy the attention of those who place the supreme good in that which immediately administers to the physical necessities or luxuries of life.

Thank you very much, Mr. Chairman.

Mr. DADDARIO. Thank you, doctor.

Mr. Vivian.

Mr. VIVIAN. I must comment on your remarks about the SIE. You say:

> The problem has led some investigators, especially those in the foremost rank of workers on theoretical problems, to maintain mailing lists of colleagues in order to exchange mimeographed previews of forthcoming papers.

That is an extremely familiar subject. I think I threw away most of my mailing lists a while back. I would like to point out that it cost the Federal Government a fair amount of money to maintain those mailing lists since many of the persons are being paid for Federal research activities, and they are using secretarial time and their own personal time. I had, for example, so-called McBee file for a number of years which was a very poor approximation to your computer file. I think an extension of the Science Information Exchange could be a very great asset. However, extension has to go not only to agencies but also to private researchers, and there are several hundred thousand in this category, so that you may have to reproduce several hundred thousand items. Probably the only inexpensive way of doing this is through a centralized system. What concerns me about the SIE system, which I think is basically an excellent approach, is the following: How often do you report back to the investigators or to the sponsoring agencies, the agencies one step above the individual investigators, what the SIE says they are doing?

Dr. RIPLEY. I think this is a tailormade operation. In certain instances the agencies ask for an overview of what they are doing, and that this is—I am not sure if it is exactly scheduled at this point, so that by "tailor made" I mean that it comes and goes. In some cases agencies do ask for overviews and reviews and in some cases they may wait for a while. In many cases it is done by interagency exchange at meetings. The SIE sponsors meetings with the agency heads and during this time present reports about the current product. That sort of thing is visualized.

Mr. VIVIAN. I would like to stress that you will not have really an efficient system for SIE until it is down to the individual level because within many organizations there are significant differences between individuals. If you do not have an automatic report-back procedure which shows how the entry looks on the SIE files, you will miss an enormous amount of valuable work. This happens very frequently.

Dr. RIPLEY. We do have that, Congressman Vivian. I know, for example, when I am doing something I get one of these forms to fill out, and this is quite automatic. This is sent back and dovetailed into the general information file and then summaries of these are brought together at these meetings. So I think they are very well aware that you can't ever let the information lie fallow, and certainly as an individual investigator, as probably you yourself experienced, one does get these forms once a year from the agency asking you to get the forms back in and give summaries.

Mr. VIVIAN. Let me ask a question: I will localize it simply for pertinence. Suppose I were to pick up the phone book, say, for the University of Michigan in my district and I was to arbitrarily pick the 10th name down the list in the department of physiology. Assuming he is performing research, if I asked him if a record of his investigation is held in SIE, is he likely to say yes or no, and is he likely to know what is held there?

Dr. RIPLEY. He is likely to say "Yes." You can't force these people to do it.

Mr. VIVIAN. I understand that.

Dr. RIPLEY. He is likely to say "Yes" and he is likely to have had some communications within the past 6 months implying that there is an awareness on their part that he is doing this and a desire by them to get information back into the system.

Mr. VIVIAN. Has he ever seen a report back of what supposedly he is doing?

Dr. RIPLEY. Yes.

Mr. VIVIAN. He has actually seen a record?

Dr. RIPLEY. Yes; he should have. Yes, you receive each year a duplicate of your project notices to be revised as needed.

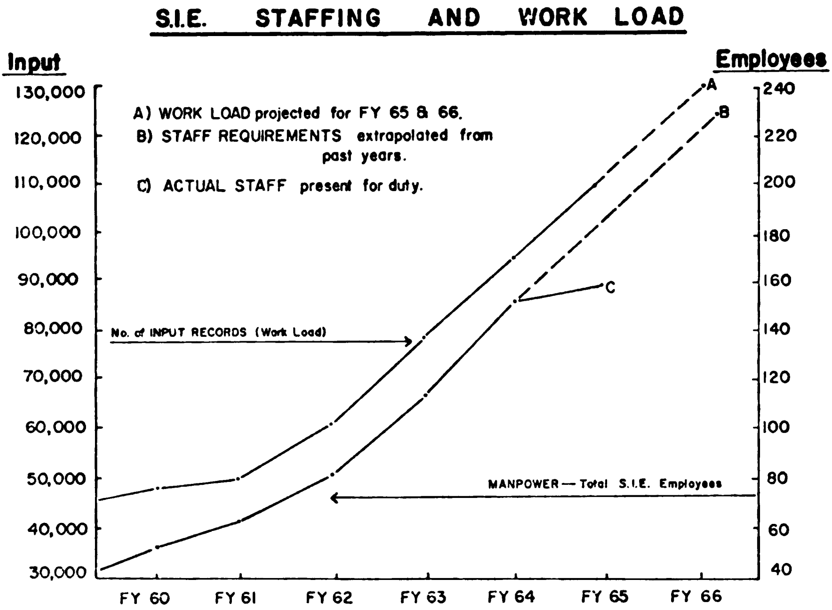
Mr. VIVIAN. But he actually does receive this report back?

Dr. RIPLEY. He should, yes; if he hasn't dropped it in the wastebasket or done something which is a factor of human error involved.

Mr. VIVIAN. I will try to go down a list in a telephone book and take 10 names and see how we run out on this matter.

Dr. RIPLEY. We have some of these tables on the operations and workload of the SIE, and I would be very glad to enter them into the record showing some of the feedback process involved, which I think is what we have been discussing.

(The information referred to follows:)



SCIENCE INFORMATION EXCHANGE

Budget and personnel, fiscal years 1961–65

	During period	Funding
Personnel employed:		
62–65	1960–61	643, 089
65–87	1961–62	850, 000
87–127	1962–63	1, 000, 000
127–153	1963–64	1, 500, 000
153–160	1964–65	2, 000, 000

SIE operations, fiscal years 1964–65

	1964	1965
INPUT		
Projects processed	69, 500	[1] 75, 463
Proposals processed	25, 312	25, 717
OUTPUT		
Major special projects (100 percent Federal requestors)	7	16
Administrative compilations (87 percent Federal requestors)	114	159
Subject questions (79 percent Federal) [2]	4, 413	5, 341
Investigator reports (93 percent Federal requestors)	29, 476	38, 110
Automatic distribution (99 percent Federal requestors)	356, 779	430, 084
Total NRP's distributed (all services)	697, 135	865, 976

[1] Basic DOD fiscal year 1965 research records promised for August 1965, not included.
[2] The SIE log of 792 subject requests for sample period April–May–June 1964 actually shows the following data:

36 percent were from Federal Government officials and employees;
25 percent were from Federal contractors or grantees (including nonprofit and industrial laboratories);
18 percent were from laboratories that had Federal grants or contracts in the same subject fields requested (including nonprofit and industrial laboratories);
21 percent were from sources not identifiable as Federally supportive. Therefore, 79 percent of the subject requests were geared to the Federal research program.

Source: Science Information Exchange, July 19, 1965.

General Significance of SIE Compilations

Compilations of data from Science Information Exchange (SIE) are subject to some inherent limitations and exceptions. Wherever possible, SIE will note and estimate the significance of these conditions as they apply to each compilation. There are also the general limitations noted below that should be recognized in order to avoid possible misinterpretation, confusion, and contradictory conclusions, when comparing these data with other sources.

SIE is an inventory of research tasks, where "task" means a small uniquely identified unit of research work.

The dollar values recorded by SIE are intended only to show the annual level of effort (or support) for each individual task.

Sums, totals, and compilations of SIE's research task records are not designed to reflect budget data. Therefore, SIE dollar sums and totals cannot be reconciled with budgets that are essentially inventories of total dollars. The latter allocates all R. & D. dollars to specified categories. SIE counts only those dollars that are annually allocated to a selected list of items identified as basic and applied research tasks. This does not include many categories of overhead, general support, construction, fellowships, etc.

SIE dollar sums and totals can be used as a comparative index of relative emphasis and distribution among agencies, or recipients, or geographical areas, of subject fields, etc., for one or a series of years, if the inherent limitations and exceptions are clearly recognized in each case and applied to the derivation of conclusions. For example:

(1) SIE receives no research records classified for national security.

(2) SIE receives no dollar values for most in-house research tasks.

(3) At this time, SIE receives few records of development projects and programs.

In comparing SIE data with other sources, it should be noted that many projects and tasks are on the borderline between applied research, advanced technology, and development. The decision for inclusion or exclusion is arbitrary, and may differ among agencies, and by individuals. These may total fairly large sums, and corresponding discrepancies.

(4) SIE focuses on the research task, per se. Contracts, grants, and funds allocated to general research support, such as interdisciplinary laboratories, institutional grants, etc., that are not related to specific research tasks may not come to SIE or may be accounted differently.

(5) SIE registers research tasks according to the fiscal year in which the research began. This may or may not agree with the fiscal year in which the funds were budgeted, committed, or obligated.

(6) SIE records the annual cost (level of effort) for a grant or contract that may extend over several years. Some agencies assign the budget cost of a single 3-year grant to 1 fiscal year, in compiling their reports.

(7) SIE can only report on tasks that have been registered by the participating agencies. All Federal agencies do not register their entire programs so that SIE cannot guarantee complete coverage for any given program, subject, or agency.

(8) The SIE collection has grown rapidly over the years as agencies have initiated and/or increased their registration. Comparative trends over a series of years in some categories may reflect the growth of the Exchange rather than changing emphasis in the research area or program.

(9) With any compilation, SIE will note and estimate the significance of these limitations, as far as possible, if requested to do so.

Distribution of physical and life sciences projects registered at SIE [1]

LARGE RESEARCH PROGRAMS

	Life	Physical	Inter-disciplinary	Total projects
	Percent	*Percent*	*Percent*	
Veterans' Administration	95		5	6,572
Agriculture	86	1	13	9,336
HEW	85	1.3	12	20,982
NSF	52	39	9	4,655
AEC	36	50	14	2,528
Interior	36	57	8	2,680
DOD	30	56	12	7,179

See footnotes at end of table, p. 529.

Distribution of physical and life sciences projects registered at SIE[1]—Continued

SMALL AGENCY PROGRAMS (LESS THAN 1,000 PROJECTS)

Labor	90		10	94
State	60	10	30	29
Tennessee Valley Authority	22	45	33	123
NASA	15	62	23	778
FAA	13	81	6	501

[1] Based on fiscal year 1964 projects on tape.

Input status[1] *to the science information exchange by Federal departments and agencies on research projects*

DEPARTMENT	*Status*
1. Agriculture:	
Agricultural Marketing Service	Complete.
Agricultural Research Service	Do.
Cooperative State Experiment Station Service	Do.
Economic Research Service	Do.
Farmer Cooperative Service	Do.
Forest Service	Do.
2. Commerce:	
Area Redevelopment	Target review.
Bureau of the Census	Do.
Bureau of Public Roads	Complete.
Coast and Geodetic Survey	Do.
Maritime Administration	Requested.
National Bureau of Standards	Complete.
Patent Office	Target review.
Weather Bureau	Complete.
3. Defense:	
Advanced Research Projects Agency	Target.
Defense Atomic Support Agency	Do.
Army, Department of:	
Army Research Office; Ch. R. & D.; TAGO	Completing.[3]
Army Medical R. & D. Command; AMS	Complete.
Corps of Engineers (civil works program)	Do.
Other technical services commands	Completing.[3]
Navy, Department of:	
Office of Naval Research	Complete.
Bureau of Medicine and Surgery	Do.
Bureaus of Naval Weapons, Ships, Yards and Docks	Completing.[3]
U.S. Marine Corps, Bureau of Naval Personnel, other	Do.[3]
Air Force, Department of:	
Systems Command:	
Research and Technology Division	Complete.
Aerospace Medical Division	Do.
Office of Aerospace Research	Do.
4. Health, Education, and Welfare:	
Food and Drug Administration	Do.
Office of Education	Do.
Public Health Service:	
Bureaus of Medical Services, States Services	Do.
National Institutes of Health	Do.
Social Security Administration	Do.
Vocational Rehabilitation Administration	Do.
Welfare Administration:	
Childrens Bureau	Do.
Bureau of Family Services	Do.
5. Interior:	
Bureau of Commercial Fisheries	Do.
Bureau of Mines	Do.
Bureau of Reclamation	Do.
Bureau of Sport Fisheries and Wildlife	Do.
Division of Federal Aid	Completing.

See footnotes at end of table.

Input status[1] *to the science information exchange by Federal departments and agencies on research projects*—Continued

	Status
5. Interior—Continued	
Geological Survey	Complete.
National Park Service	Do.
Office of Coal Research	Do.
Office of Saline Water	Do.
Bureau of Land Management	Do.
Bonneville Power Administration	Do.
Office of Water Resources Research	Do.
6. Labor:	
Office of Manpower, Automation, and Training	Do.
Bureau of Labor Statistics	Do.
Bureau of Employment Security	Target review.
7. Post Office	Do.
8. State:	
Agency for International Development	Completing.
Departmental projects	Target review.
9. Treasury: U.S. Coast Guard	Requested.

AGENCIES

1. Arms Control and Disarmament Agency	Target review.
2. Atomic Energy Commision:	
Division of Biology and Medicine	Complete.
Division of Research	Do.
Division of Isotopes Development	Completing.
Division of Reactor Development	Partial.
3. Federal Aviation Agency:	
Systems Research and Development Service	Complete.
Office of Aviation Medicine	Do.
4. Federal Communications Commission	Target review.
5. Housing and Home Finance Agency	Requested.
6. National Aeronautics and Space Administration:	
Extramural	Partial.
Intramural	Requested.
7. National Science Foundation:	
Biological and Medical Division	Complete.
Engineering Division	Do.
Mathematical and Physical Science Division	Do.
Social Science Division	Do.
Office of Antarctic Programs	Completing.
Office of Scientific Information Services	Do.
8. Office of Emergency Planning	Target review.
9. Small Business Administration	Do.
10. Smithsonian Institution	Complete.
11. Tennessee Valley Authority	Do.
12. Veterans' Administration	Do.

[1] Input status code:
Complete—All appropriate projects have been registered, as far as is known.
Completing—Bulk of the appropriate projects have been or are being registered. Collection is on schedule but not yet complete.
Partial—Arrangements not completed for registration of all appropriate projects. Some projects in.
Requested—Program registration requested, but no presently active projects received to date.
Target review—Assessment of appropriate programs is underway.
Target—Known appropriate programs.
Promised—Arrangements completed. Records promised for delivery in weeks.
[2] Completion assured for all basic research units only.

Source: Science Information Exchange, July 1, 1965.

Project records on magnetic tape, SIE, as of June 1, 1965

Agency	Extramural			Intramural			Total	
	1964	1965	1966	1964	1965	1966	1964	1965
Agriculture	6, 868	7, 008	1	2, 691	2, 608	0	9, 559	9, 616
Commerce	88	1, 220	0	912	1, 247	0	1, 000	2, 467
Defense	5, 497	2, 209	3	1, 772	1, 048	0	7, 269	3, 257
Health, Education, and Welfare	18, 501	14, 718	13	2, 278	300	0	20, 779	15, 018
Interior	470	910	3	2, 210	2, 148	0	2, 680	3, 058
Labor	88	65	2	6	4	0	94	69
State	28	23	0	1	0	0	29	23
Atomic Energy Commission	1, 410	613	0	1, 118	387	0	2, 528	1, 000
Federal Aviation Agency	0	3	0	501	2	0	501	5
Housing and Home Finance Agency	1	0	0	0	0	0	1	0
NASA	778	292	1	0	0	0	778	292
National Science Foundation	4, 653	3, 462	2	0	0	0	4, 653	3, 462
Small Business Administration	0	0	0	0	0	0	0	0
Smithsonian Institution	0	1	0	1	296	0	1	297
Tennessee Valley Authority	8	15	0	117	90	0	125	105
Veterans' Administration	0	0	0	6, 572	3, 320	0	6, 572	3, 320
Total Government records							56, 559	41, 989
Foundations and societies							4, 492	3, 803
Universities							111	181
State and local							5, 755	6, 189
Private industry							91	102
Nonsupported							3	22
Total non-Government projects							10, 452	10, 297
Total projects registered							67, 011	52, 286

Active input sources by type, fiscal year 1964–65

FISCAL YEAR 1964

Federal bureaus	55
State welfare, medical, mental health (32) and miscellaneous programs	35
University sources	16
Foundations and associations	110
Commercial firms	27
Voluntary foreign sources	18
Total sources	261

FISCAL YEAR 1965

Federal bureaus	88
State agricultural (41), wildlife, conservation and water resources (36), health and miscellaneous (12) programs	89
University sources	36
Foundations and associations	125
Commercial firms	59
Voluntary foreign sources	21
Total sources	388

Agencies Supporting Research Reported to Science Information Exchange

FEDERAL

Departments:
- **Agriculture:**
  - **Agricultural Marketing Service.**
  - **Agricultural Research Service.**
  - **Cooperative State Experiment Station Service.**
  - **Economic Research Service.**
  - **Farmer Cooperative Service.**
  - **Forest Service.**

AGENCIES SUPPORTING RESEARCH REPORTED TO SCIENCE INFORMATION EXCHANGE—Continued

- Departments—Continued
  - Commerce:
    - Bureau of the Census.
    - Bureau of Public Roads.
    - Coast and Geodetic Survey.
    - Maritime Administration.
    - National Bureau of Standards.
    - Weather Bureau.
  - Defense:
    - Army, Department of:
      - Army Research Office; Ch. R. & D.; TAGO.
      - Army Medical R. & D. Command; AMS.
      - Corps of Engineers (civil works program).
      - Other Technical Service Commands.
    - Navy, Department of:
      - Office of Naval Research.
      - Bureau of Medicine and Surgery.
      - Bureaus of Naval Weapons, Ships, Yards and Docks.
      - U.S. Marine Corps, Bureau of Naval Personnel, other.
    - Air Force, Department of:
      - Systems Command:
        - Research and Technology Division.
        - Aerospace Medical Division.
  - Health, Education, and Welfare:
    - Food and Drug Administration.
    - Office of Education.
    - Public Health Service:
      - Bureaus of Medical Services, States Services.
      - National Institutes of Health.
    - Social Security Administration.
    - Vocational Rehabilitation Administration.
    - Welfare Administration:
      - Children's Bureau.
      - Bureau of Family Services.
  - Interior:
    - Bureau of Commercial Fisheries.
    - Bureau of Mines.
    - Bureau of Reclamation.
    - Bureau of Sport Fisheries and Wildlife Division of Federal Aid.
    - Geological Survey.
    - National Park Service.
    - Office of Coal Research.
    - Office of Saline Water.
    - Bureau of Land Management.
    - Bonneville Power Administration.
    - Office of Water Resources Research.
  - Labor:
    - Office of Manpower, Automation, and Training.
    - Bureau of Labor Statistics.
    - Bureau of Employment Security.
  - Post Office.
  - State:
    - Agency for International Development.
    - Departmental projects.
  - Treasury: U.S. Coast Guard.
- Agencies:
  - Atomic Energy Commission:
    - Division of Biology and Medicine.
    - Division of Research.
    - Division of Isotopes Development.
    - Division of Reactor Development.
  - Federal Aviation Agency:
    - Systems Research and Development Service.
    - Office of Aviation Medicine.
  - Housing and Home Finance Agency.

AGENCIES SUPPORTING RESEARCH REPORTED TO SCIENCE INFORMATION EXCHANGE—Continued

Agencies—Continued
- National Aeronautics and Space Administration:
  - Extramural.
  - Intramural.
- National Science Foundation:
  - Biological and Medical Sciences Division.
  - Engineering Division.
  - Mathematical and Physical Sciences Division.
  - Social Science Division.
  - Office of Antarctic Programs.
  - Office of Scientific Information Services.
- Smithsonian Institution.
- Tennessee Valley Authority.
- Veterans' Administration.

NON-FEDERAL

Commercial:
- Adolph Coors Co.
- Allied Chemical Co.
- American Dehydrators & Associates.
- American Gas Co.
- American Petroleum Institute.
- Beechcraft Research & Development.
- Bennett Chemicals Co.
- Bethlehem Steel Co.
- Blast Furnace Research, Inc.
- The Boeing Co.
- Colloidal Products Co.
- Colorado Cattle Feeders Association.
- Colorado Hookey Business Association.
- Colorado Turkey Federation.
- Commercial Solvents Corp.
- Consumers Cooperation Association.
- Coordinating Research Council.
- Edison Electric Institute.
- East Pacific Co.
- Fansteel Metallurgical Co.
- Gates Rubber Co.
- Geigy Agricultural Chemicals.
- General Electric Co.
- General Motors Corp.
- Grace (W. R.) & Co.
- Great Western Sugar Co.
- Hoffman LaRoche, Inc.
- Hollar & Co.
- Indianapolis Power & Light Co.
- International Mining & Chemistry.
- International Pharmaceutical Corp.
- ITT Communications Circuits.
- Kennecott Copper Co.
- Lear Siegler, Inc.
- Little Monatee Utilities.
- Manufacturing Chemists' Association, Inc.
- Merck & Co., Inc.
- Morton Chemical Co.
- National Steel Corp.
- National Turkey Federation.
- Northern Products Association.
- Noyden Sales, Inc.
- Oregon Metallurgical Corp.
- Owens Illinois, Inc.
- Philco Co.
- Pillsbury Co.
- Plateau Natural Gas Co.
- Radio Corporation of America.

AGENCIES SUPPORTING RESEARCH REPORTED TO SCIENCE INFORMATION EXCHANGE—Continued

Commercial—Continued
- Scott Paper Co.
- Shell Chemical Co.
- Simpson-Lee Co.
- Socony-Mobil Co.
- Systems Development Corp.
- Texas Power and Light Co.
- Union Carbide Corp., Linde Division.
- Tippits-Abbett-McCarthy-Stratton.
- Utah Construction & Mining Co.
- Wah Chang Corp.
- Wayer Haeuser Co.

Foreign:
- Alcoholism & Drug Addiction Research Foundation of Canada
- Arthritis & Rheumatism Society, Ontario Division.
- Arthritis & Rheumatism Society, National Office.
- Canadian Department of Veteran Affairs.
- Canada, Department of National Health and Welfare.
- Canadian Defense Research Board.
- Canadian Life Insurance Officers Association.
- Canadian Heart Foundation.
- Canadian Mental Health Association.
- Canadian National Cancer Institute.
- Canadian Tuberculosis Association.
- Medical Research Council of Canada.
- Muscular Dystrophy Association of Canada.
- New Zealand Forest Service.
- Ontario Cancer Treatment and Research Foundation.
- Societe Minere et Metallugique.
- University of British Columbia.
- Foreign Universities (miscellaneous).
- France, Government of.
- College of Medicine, Strasbourg, France.
- Canadian Paper & Pulp Institute.

Foundations and societies:
- American Academy of Arts and Sciences.
- American Association for the Advancement of Science.
- American Association of Petroleum Geologists.
- American Association of University Women.
- American Cancer Society.
- American Dairy Association.
- American Diabetes Association.
- American Friends Service Committee.
- American Gas Association.
- American Heart Association.
- American Medical Research Institute.
- American Osteopathic Association.
- American Otological Association.
- American Petroleum Institute.
- American Philosophical Society.
- Arctic Institute of North America.
- Association for the Aid of Crippled Children.
- Astor, Vincent Foundation.
- Avalon Foundation.
- Babcock, Mary Reynolds Foundation.
- Biddle Foundation.
- Bolinger Foundation.
- Bright Star Foundation.
- Carnegie Corp. (N.Y.).
- Childs (Jane Coffin) Memorial Fund.
- Cleveland Associates Fund.
- Cleveland Foundation.
- Commonwealth Fund.

AGENCIES SUPPORTING RESEARCH REPORTED TO SCIENCE INFORMATION EXCHANGE—Continued

Foundations and societies—Continued
Coordinating Research Council.
Council for Tobacco Research, U.S.A.
Council on Library Resources.
Devereux Foundation.
Easter Seal Foundation.
Epilepsy Foundation.
Field (Marshall) Foundation.
Fleischman (Max C.) Foundation, Nevada.
Ford Foundation.
Ford (Vincent and Edith) Fund.
Foremost Research Foundation.
Fort Howard Paper Foundation.
Forest Park Foundation.
Foundation's Fund for Research Psychiatry.
Frasch (Herman) Foundation.
Garvey Foundation.
Grant Foundation.
Guggenheim (John) Memorial Foundation.
Hartford (John A.) Foundation.
Health Research and Services Foundation.
Hematology Research Foundation.
Hill Family Foundation.
Hood (Charles) Dairy Foundation.
Houston Endowment.
Human Ecology Fund.
Indianopolis Foundation.
International Harvester Foundation.
James Foundation, N.Y.
Kalamazoo Foundation.
Kellog (W. K.) Foundation.
Kennedy (J. F., Jr.) Foundation.
Killogore (Florence) Foundation.
Lalor Foundation.
Leukemia Society, Inc.
Life Insurance Medical Research Foundation.
Listeman (Marguerite) Foundation.
Macy, Josiah, Foundation.
Markle Foundation.
The Medical Foundation, Inc.
Mellon Education and Charitable Trust.
Meyer (Eugene and Agnes) Foundation.
Milbank Memorial Fund.
Morris Animal Foundation.
Muscular Dystrophy Association of America.
Myasthenia Gravis Foundation, Inc.
National Association for Mental Health.
National Council to Combat Blindness.
National Dairy Council.
National Foundation Committee on Medical Research.
National Foundation for Neuro-Muscular Diseases.
National Multiple Sclerosis Society.
National Research Council, Drug Addiction and Narcotics.
National Research Council, Committee on Sex.
National Society for the Prevention of Blindness.
National Tuberculosis Society.
National Vitamin Foundation.
New Haven Foundation.
New World Foundation.
N.Y. Academy of Osteopathy.
New York Foundation.
Nutrition Foundation.
Old Dominion Foundation.

AGENCIES SUPPORTING RESEARCH REPORTED TO SCIENCE INFORMATION EXCHANGE—Continued

Foundations and societies—Continued
- Pfieffer Research Foundation.
- James Picker Foundation.
- Population Council, Inc.
- Refrigeration Research Council.
- Research Corp., Williams Waterman.
- Research To Prevent Blindness.
- Resources of the Future.
- Ripple (Fanny E.) Foundation.
- Rockefeller Boards Foundation.
- Rockefeller Foundation.
- Rosen (Samuel) Family Foundation.
- Runyon (Damon) Memorial Fund for Cancer Research.
- Russell Sage Foundation.
- San Francisco Foundation.
- Sciafe (Sarah Mellon) Foundation.
- Schlieder (Edward C.) Educational Foundation.
- Segal Research Fund.
- Selby (William and Marie) Foundation.
- Smith Kline, and French Foundation.
- Social Science Research Council.
- Society of the Sigma Xi.
- Stewart (A. and M.) Trust Fund.
- Stone (W. C. and J. V.) Foundation.
- Sulpher Institute.
- Teagle Foundation, Inc.
- Turrell Foundation.
- United Cerebral Palsy.
- U.S. Steel Foundation.
- Victorian Foundation.
- Whitehall Foundation.
- Welch (Roberta) Foundation.
- Whitney (Helen Hay) Foundation.
- Wieboldt Foundation.
- Kettering (Charles F.) Foundation.
- Kresge Foundation.

State-city governments:
- State of Alaska: Agricultural Experiment Station.
- State of Arizona: Agricultural Experiment Station.
- State of Arkansas: Agricultural Experiment Station.
- State of California:
  - Agricultural Experiment Station.
  - Department of Mental Hygiene.
  - Mental health research program.
  - Department of Fish and Game.
  - Health Foundation, San Diego County.
  - Department of Conservation.
  - State Water Quality Board.
- State of Colorado:
  - Agricultural Experiment Station.
  - Department of Game, Fish, and Parks.
  - Mental health research program.
- State of Connecticut:
  - Agricultural Experiment Station.
  - Mental health research programs.
- State of Delaware: Agricultural Experiment Station.
- State of Florida:
  - Agricultural Experiment station.
  - Florida Game and Fresh Water Fish Commission.
  - Mental health research program.

AGENCIES SUPPORTING RESEARCH REPORTED TO SCIENCE INFORMATION EXCHANGE—Continued

State-city governments—Continued
- State of Georgia:
  - Agricultural Experiment Station.
  - State Fish and Game Commission.
  - Milledgeville State Hospital.
  - Health and Hospital Planning Council.
- State of Hawaii: Agricultural Experiment Station.
- State of Idaho: Agricultural Experiment Station.
- State of Illinois:
  - Agricultural Experiment Station.
  - State Geological Survey.
  - Mental health research programs.
  - State Water Survey Division.
  - Department of Conservation.
- State of Indiana:
  - Agricultural Experiment Station.
  - Indiana State Highway Commission.
  - State flood control and water research.
  - Geological Survey.
  - Mental health research programs.
- State of Kansas: Agricultural Experiment Station.
- State of Kentucky: Agricultural Experiment Station.
- State of Louisiana:
  - Agricultural Experiment Station.
  - Wildlife and Fisheries Commission.
  - Mental health research programs.
- State of Maine: Agricultural Experiment Station.
- State of Maryland:
  - Agricultural Experiment Station.
  - Water Pollution Control Commission.
- State of Massachusetts:
  - Agricultural Experiment Station.
  - Division of Marine Fisheries.
  - Department of Natural Resources.
- State of Michigan: Mental health research program.
- State of Minnesota:
  - Agricultural Experiment Station.
  - Department of Conservation.
- State of Mississippi:
  - Agricultural Experiment Station.
  - Game and Fish Commission.
- State of Montana: Agricultural Experiment Station.
- State of Nebraska: Agricultural Experiment Station.
- State of Nevada: Agricultural Experiment Station.
- State of New Hampshire: Agricultural Experiment Station.
- State of New Jersey:
  - Agricultural Experiment Station.
  - Department of Conservation.
- State of New Mexico: Agricultural Experiment Station.
- State of New York:
  - Agricultural Experiment Station.
  - Medical and Health Research Association of New York City.
  - Conservation Department.
- State of North Carolina:
  - Agricultural Experiment Station.
  - Wildlife Resources Commission.
- State of North Dakota: Agricultural Experiment Station.
- State of Ohio:
  - Agricultural Experiment Station.
  - Department of Natural Resources.

AGENCIES SUPPORTING RESEARCH REPORTED TO SCIENCE INFORMATION EXCHANGE—Continued

State-city governments—Continued
- State of Oregon:
  - Agricultural Experiment Station.
  - Oregon Fish Commission.
  - Oregon Game Commission.
- Commonwealth of Pennsylvania:
  - Agricultural Experiment Station.
  - Department of Public Welfare.
  - Pennsylvania Fish Commission.
  - Pennsylvania Game Commission.
  - Department of Forest and Water.
- Puerto Rico: Agricultural Experiment Station.
- State of Rhode Island: Agricultural Experiment Station.
- State of South Carolina:
  - Agricultural Experiment Station.
  - Wildlife Resources Department.
- State of South Dakota: Agricultural Experiment Station.
- State of Tennessee: Agricultural Experiment Station.
- State of Texas: Agricultural Experiment Station.
- State of Utah: Agricultural Experiment Station.
- State of Vermont: Agricultural Experiment Station.
- State of Virginia:
  - Agricultural Experiment Station.
  - Department of Conservation and Economics.
  - Virginia Institute of Marine Science.
- State of Washington:
  - Agricultural Experiment Station.
  - Mental health research program.
- State of Wisconsin:
  - Agricultural Experiment Station.
  - Conservation Department.
- State of Wyoming: Agricultural Experiment Station.

Universities (registering or negotiating):
- Alabama, University of.
- American University.
- Arizona State College.
- Arizona State University.
- Arizona, University of.
- Arkansas, University of.
- California College of Medicine.
- California State College at Hayward.
- California, University of.
- California, University of—Scripps Institute of Oceanography.
- Carnegie Institute of Technology.
- Chicago, University of.
- Clemson University.
- Colorado State University.
- Colorado, University of.
- Columbia University.
- Connecticut, University of.
- Cornell University.
- Delaware, University of.
- Denver, University of.
- Florida, University of.
- George Washington University.
- Georgia Institute of Technology.
- Hahnemann Medical College.
- Illinois, University of.
- Indiana University.
- Iowa State University.
- Jefferson Medical College.
- Johns Hopkins University.
- Kansas State University.
- Kansas, University of.

AGENCIES SUPPORTING RESEARCH REPORTED TO SCIENCE INFORMATION EXCHANGE—Continued

Universities (registering or negotiating)—Continued
- Kentucky, University of.
- Louisiana State University.
- Loyola University (Chicago).
- Massachusetts, University of.
- Miami, University of.
- Michigan State University.
- Mississippi, University of.
- Missouri, University of.
- Nebraska, University of—College of Medicine.
- New Mexico, University of.
- Northwestern University.
- Ohio State University.
- Oklahoma State University.
- Oregon State University.
- Oregon, University of.
- Pennsylvania State University.
- Pittsburgh, University of.
- Purdue University.
- Seton Hall College of Medicine and Dentistry.
- South Carolina, University of.
- Southern California, University of.
- Southwest Texas State College.
- Stanford University.
- Stevens Institute of Technology.
- St. John's University.
- Texas A. & M. College.
- Texas Christian University.
- Texas, University of.
- Trinity University.
- Upper Iowa University.
- Washington State University.
- Wastern Reserve University.
- West Texas State University.
- Wisconsin, University of.
- Woman's Medical College.

Mr. VIVIAN. I have two other questions if time is available.

On page 10 of your remarks you indicate that—

> the Smithsonian welcomes a public discussion of our national policy for science, believing that a positive desire for new knowledge must be widely shared among the people before it can be secure among the aims of Government.

That is a very accurate statement. I would like to know whether or not you feel there are more productive things that can be done in this direction than are presently being done?

Dr. RIPLEY. I think there is room for always a continuing investigation and exchange of information at different levels in government on these subjects, and that is one reason I welcome these sorts of opportunities to discuss among Members of the Congress and ourselves the kinds of things we are carrying on. There is just so much one can do in any one time.

Mr. VIVIAN. Would you be more specific? NASA space launches such as Gemini are nationally televised. I am curious to know whether you feel the health sciences or the social sciences have similar access to the public interest.

Dr. RIPLEY. I don't suppose they really do. The health sciences do through the various sorts of exhibits of museums of science and industry and human biology exhibits and so on.

Mr. VIVIAN. Do you have any opportunity, for example, to present a television program once or twice a week, or do you have cooperative arrangements with university educational stations or with the major networks to disseminate information on some of the advances in the more human facets of science?

Dr. RIPLEY. We don't have as much opportunity as we would like. We have not particularly received support. The field of public information, so called, has always been one which seems to be suspect in the minds of government, and I might say we have not received as much support as we would like for this sort of thing.

Mr. VIVIAN. Do you have an authorization, for example, to prepare not only museum displays but also television shorts on various subjects? Do you have an authorization and budget for this purpose?

Dr. RIPLEY. We have an authorization but no budget for it. We have a blanket authorization which has allowed us in the past to cooperate with private radio, for example, in the preparation of a radio program which was quite successful but which for budgetary reasons we finally had to discontinue. I have been exploring at the present time methods of getting private contributions from foundations and business interests to try and get back into the field of educational radio and television.

Mr. VIVIAN. There is NET. They do work closely with the Smithsonian or not?

Dr. RIPLEY. No, not at this point. But we are presently preparing as a tickler, I might call it, a short movie which will be shown on television of some of the panorama of the development of American science in the 19th century, represented by the Smithsonian's activities, to be released at the time of the bicentennial in September. I think myself that this is enormously important and we should be involved.

Mr. VIVIAN. Mr. Chairman, I have several other questions, but I may be prohibiting other members from asking questions.

Mr. DADDARIO. I think you should continue.

Mr. VIVIAN. On page 9 you refer to a lack of sufficient progress or—

not progressing sufficiently rapidly in investigation of life processes, chemistry, human psychology, and physical processes at all levels.

There has been some previous discussion of that general subject. I am curious to know whether you think it is a result of the Government organizational structure at this time or some other situation. Is it because the governmental research organizations are not properly organized?

Dr. RIPLEY. I wouldn't say that at all. Always it seems we don't know enough about these agencies. The massive assaults in certain areas, investigations in life processes, chemistry and psychology and so on, has been tremendous. There is no doubt about it. The results haven't been coming in——

Mr. VIVIAN. Why do you use the words "not progressing sufficiently rapidly"?

Dr. RIPLEY. By "progressing" what I mean is essentially the results rather than the push toward the process. I think there have been in some areas, particularly health, tremendous thrusts toward solving the problems.

Mr. VIVIAN. Do you consider that the National Science Foundation is putting sufficient support on these particular subjects?

Dr. RIPLEY. I don't know that I want to speak to this as to the exact elements of the National Science Foundation and the National Science Institutes of Health. This is an area which I am not too familiar with. Certainly in areas of social psychology and environmental biology I feel we are not getting enough support and that probably processes and investigations could be furthered by more support. This is the sort of thing I think the NCF, if given more funds, could do very profitably.

Mr. VIVIAN. On page 4 you indicate:

The research efforts of the Smithsonian come to a focus in three areas, the nature of the university, the organization of life, and nature and history of man's culture.

It is my general feeling that the Smithsonian stresses the last of those three, and that the Smithsonian is the historian of the scientific world. The previous remarks you made on the Smithsonian being active in astrophysics, earth sciences, and marine biology, suggests that you view your role as being more than historical. I gather that is the case.

Dr. RIPLEY. Yes, that is the case.

Mr. VIVIAN. What percentage of your budget would fit into what I will call the nonhistorical category? I am interpreting history in the broad context.

Dr. RIPLEY. Actually about a third; no, a little more than a third, nearly 35 percent, of our budget goes into natural science and research plus, of course, we get additional grants from NASA, for example, and other agencies for performing missions and tasks for them.

This is perhaps an outgrowth of the familiar concept in the public mind, as well as in scientists' minds, of the word "museum." It has a kind of strange dead connotation, and it implies at best a historical approach toward knowledge and the accumulation of knowledge, and, of course, the Smithsonian is very much more than a museum. In this sense it is like an iceberg; $8 million of our annual budget are involved in original research and related improvements in physical plant.

Mr. VIVIAN. I understand you have been active in astrophysics. I am also aware that the Smithsonian is used for some of the tracking activities in the space program. However, I have the feeling that the astrophysics work might drift more toward NASA at the present time or into NSF's general support rather than being continued actively by the Smithsonian. I realize that may not be to your interest or liking, but do you not perhaps see your role changing from what might have been quiet science becoming suddenly active?

Dr. RIPLEY. I think the Smithsonian's interest in astrophysics, which is historical and old, has kept up very well with present developments. We have people on our staff who have been working for years in the area of meteoretics, tektites, and the analysis of material which has arrived from outer space. We have people working in radiation biology directly as an outgrowth of our own interests in astrophysics who are performing I would say not only adequately but

inventively, originally, and basically in areas which are keeping up very nicely with the general field.

Mr. VIVIAN. What other agencies in the Government today are specializing in astrophysics? I would assume NASA and NSF are active in that area.

Dr. RIPLEY. NSF in a granting form but not performing original research perhaps. We are concerned with performing research ourselves.

Mr. VIVIAN. What other agencies would be involved, other than the two I mentioned?

Dr. RIPLEY. I suppose NASA and—let's see—the Joint Institute for Laboratory Astrophysics of the Bureau of Standards, at Boulder. There is also NASA's Goddard Institute for Space Studies in New York.

Mr. VIVIAN. Any others?

Dr. RIPLEY. Perhaps I should mention Dr. Friedman at the Naval Research Laboratory and its Hulbert Center.

Mr. VIVIAN. So it is not an overpopulated field at the present moment?

Dr. RIPLEY. No, it is not a terribly overcomplicated field I would say. I think we are maintaining, as I say, a gradual growth of our own which is traditional but also capable of innovation. I would say that at such point as it becomes applied or it becomes very widely of importance we would be prepared to spin it off as we have continually spun things off in the past.

Mr. VIVIAN. Do you still operate the tracking station which you were very deeply involved in awhile back?

Dr. RIPLEY. Yes. We have these Baker-Nunn cameras which were set up under an original NSF grant as a result of our own investigations and research which we operate, largely as a series of cooperative arrangements with NASA.

Mr. VIVIAN. Thank you, Mr. Chairman.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Doctor, on page 8, you say our base is not large enough, and that an increase of 15 percent per year is all very well, but we do not have a sufficient base to start with. How should we go about establishing an acceptable base?

How can we do this, for instance, without materially affecting the quality of the work being done?

Dr. RIPLEY. I would say that the NSF must be in an excellent position to recommend, if they will, what kind of a base they would like to leap to. This is something for which they must have adequate statistics and figures, and if they choose to recommend a base, then, based on my experience of operating with them as an individual and as the head of an agency more recently, I would be inclined to agree with them. I agree with you that it is very difficult to analyze exactly at what moment there are enough investigations in prospect and investigators to perform them to sum a figure and say this is the kind of base that we need, but I would assume that NSF itself would be qualified to say that.

Mr. BROWN. Would you yield at that point?

Mr. CONABLE. Yes, I would.

Mr. BROWN. I would just like to translate this base into another framework. Actually when you talk about a base, all you are talking about is a timelag here. A 15-percent per year increase produces the base you are talking about in 5 years, so what we are really talking about is a 5-year timelag. I think our comments should be at least in part directed to the significance of whether this 5-year timelag is having a serious effect on our position in basic research.

Mr. DADDARIO. Would you comment on that?

Dr. RIPLEY. I know graduate students, I still have some, and I have had a lot of them, and I know how rapidly or not they tend to come down the pike, and I would say a 5-year lag is a critical lag. Fifteen percent per year would not make a sufficient contribution to the national level of effort.

Mr. DADDARIO. The budget which NSF submitted this year has been cut some $50 million. You would suggest that this would illustrate NSF's intention with regard to establishing a proper base?

Dr. RIPLEY. Very much so. Very much so indeed.

Mr. CONABLE. Doctor, I also note that you say:

> I believe that the time is at hand to provide secure guarantees of its national status as the principal agency of the Government for the support of basic research, guarantees of the freedom, and financial wherewithal that would permit it to discharge that mission.

What is the function of this committee in carrying out these guarantees? What would you like to see us do? What would you expect of us in this goal that you have set of a more secure position?

Dr. RIPLEY. I would say it is essentially a mood in any case, in thinking about it, a mood of generous willingness to support the science rather than specific details whether or not the degrees of reporting and accounting procedures are sufficiently strict or sufficiently lax or things of this sort. I think having worked with grants of different sorts, I cannot help but resent bitterly the kind of grant component which requires one to reply exactly how many minutes a day one has been at one's desk and when one has turned to the left or the right to answer the telephone or gone out to get a glass of water and for similar purposes, or talked to someone else who was not part of the grant funded procedures or talked to a student who came into the room by accident to ask a question, things of this sort. This kind of looking over the shoulder 1984 technique is the kind of thing in a sense that tends to compound the situation and produce petty bureaucrats and petty administrators out of people who I hope would otherwise continue to be scientists.

Mr. CONABLE. Do you feel that the scientific community resents in any way this investigation of the National Science Foundation that is going on now or do they understand that its purposes are broad in scope?

Dr. RIPLEY. I think they would be tremendously thrilled by it and greatly excited. I can't but feel always tremendously encouraged when committees of this sort do have this sort of honest and sensible inquiry. I think it is wonderful and I would hope all my colleagues felt the same way. I assume they would.

Mr. CONABLE. You are looking for us only to set a mood of support and of understanding?

Dr. RIPLEY. I assume in an atmosphere of mutual enthusiasm. This is great work, of great excitement, and of great importance to the future.

Mr. CONABLE. I think we are pretty well aware of the germinable characteristics which this agency has, and we are approaching this investigation in that mood. That is all I have, Mr. Chairman.

Mr. DADDARIO. I think Mr. Conable raises a very good point, Dr. Ripley, regarding the idea that a discussion must take place to create this atmosphere and this confidence.

This committee recommended that the percentage limitation on indirect overhead costs on research grants to universities be eliminated. We were able to make an impression within the Congress that this step should be taken, and the Appropriations Committee then took the steps to eliminate this provision in the appropriation acts for Federal agencies. It is, I think, an indication of confidence necessary to establish between ourselves and the scientific community. I would hope that this investigation of NSF would be a further step in that direction.

Mr. Brown.

Mr. BROWN. What size is the budget of the Smithsonian.

Mr. CONABLE. It is $22 million.

Dr. RIPLEY. Yes. This year it is about $22 million, Government supported operating expenses, exclusive of grants, buildings, and of our private endowments.

These are all published in our annual reports.

Mr. BROWN. In connection with the Science Information Exchange, we face a continuing problem in the overall proliferation of knowledge and in attempting to record it, and we face the administrative problem of how to coordinate this program and make it more effective. This raises the question in my mind as to the relationship between the Science Information Exchange and the other agencies of Government which are seeking to serve as centers for the dissemination of information. The Department of Commerce, for example, has a Technical Information Service which they recently opened. There are technology utilization programs in NASA, AEC, and DOD. The Science Information Exchange reports information about research in progress. This research is subsequently completed and then this moves into the field of possible technology.

Is there a problem with regard to making a coordinated whole of this process? Is there a problem of overlap, or are there areas which are not being covered in this total effort to provide information about science and technology?

Dr. RIPLEY. I would be inclined to think that our central theme is toward essentially basic research, and let the devil take the hindmost, as it were, beyond that, what comes out beyond that. I would assume that the Department of Commerce's activities are oriented in an entirely different framework, much more toward commerce, trade, technology, business, as it were, results. It is hard to conceive that there would not be possible overlaps but hard to conceive that at the same time the missions are not separate. I think it is very hard to say exactly what overlap there might be, but I would not view it as a threat because the essential importance of the information exchange type activity is that it must be done, and if it isn't done, that in itself

will be a calamity, so long as it is done and relatively well done, this is the thrust, this is the impetus for getting this thing out. I would hope that the agencies who for various reasons of security or concern about dissemination of information and so on, such as the areas that are a little more sensitive, defense, atomic energy, and so on, will gradually realize there are large components of this sort of information which can be fed into our Science Information Exchange. As I said in my testimony, these things feed on each other. The more information is given to the information exchange by an agency, the more willing they are to have an input and outflow with it, the more they then understand it, and the more they become enthusiastic about it.

Mr. BROWN. The point I am getting at is do we need to do more than to just assume this is a natural process which eventuates in a satisfactory system? In all of these other programs in the mission-oriented agencies there is a mix of material, there is basic research, there is applied research, there is technology. Some of it you might not feel should go into the Science Information Exchange, but it is all part of knowledge that is being accumulated. The overriding problem is how do we secure the optimum coordination of this tremendous flow of knowledge—the foreign journals, the reports of research in this country, all of these things. Now, I have heard that the systems being used in some of these agencies for the mechanical or electronic recording of this data are not completely compatible. You cannot use the same system to extract information from one that you can from the other. To a nontechnician in this field, this might be frustrating. Do you feel this is a problem or an area in which additional effort should be made?

Dr. RIPLEY. I feel, Mr. Brown, it is worth while pointing out that there are two slightly different principles involved here. Our Science Information Exchange, working with NSF, is really concerned in just trying to make everybody aware of what is going on right now. Most of the mission-oriented agency kinds of reporting procedures are concerned with what has already been put out. There is a difference. One is kind of a current awareness. The other is summarizing and reporting on documentation that has been produced.

Mr. BROWN. At what point do you cast out all of the material with regard to a given current research project? When it is published?

Dr. RIPLEY. No, we store it. We simply store it for retrieval. But that is easy enough on a card system, a computer system.

Mr. BROWN. Then over a period of time your files do not reflect what is currently in progress. It reflects a whole mass of stored information that is already reported in journals and so forth; is that not right?

Dr. RIPLEY. Yes. But is there anything wrong with that?

Mr. BROWN. No, but the point I am making is that this is what the other systems are doing.

Dr. RIPLEY. No, they are essentially involved in technology in other areas than basic research, and they are not building a current awareness file. It is the current awareness which starts off by being important. You don't necessarily want to throw away the card.

Mr. BROWN. Perhaps we are not adequately communicating with regard to the nature of this problem, but I do not want to belabor it.

Let me go into another area, one that Mr. Vivian mentioned; that is, the relationship of individual persons to this Science Information Exchange. Is there not also maintained by the NSF a roster of scientific and technical personnel which supposedly contains the names and backgrounds of scientific people, researchers, and so forth?

Dr. RIPLEY. Yes.

Mr. BROWN. Is there a relationship between this roster and the data which is kept in the Science Information Exchange?

Dr. RIPLEY. There is certainly a relationship, but I wouldn't say it is essentially overlapping, because the roster of personnel really involves bodies, and the current awareness program of SIE involved ideas, and the ideas may not always relate to the bodies in terms of the kind of information which you may wish to secure.

Mr. BROWN. You mentioned two areas that you said were not receiving an adequate amount of support. I think you said social psychology and environmental biology; is that right?

Dr. RIPLEY. Yes.

Mr. BROWN. And you referred to the support of the NSF and the Smithsonian?

Dr. RIPLEY. I assumed that the general NSF budget is reflected in the amount of funds that are then available to them to dispense in areas such as environmental biology. Social psychology comes over partly into NIH's interest.

Mr. BROWN. What do you mean by "environmental biology"?

Dr. RIPLEY. Environmental biology, as I visualize it, is the area where we are concerned with the relations of living organisms to their environment and the effects that the environment has upon living organisms. This is roughly what used to be called ecology, and ecology, which is a branch of biology, in which I happen to be very much interested, is essentially this concern or approach to an understanding of any living organism and the effect which it itself has on its environment and the effect which the environment has on it. This, of course, spans a very wide area of concern today especially.

Mr. BROWN. It is broad enough to include human beings then?

Dr. RIPLEY. Human ecology is certainly a little explored part of this.

Mr. BROWN. I raise the question because the subject has come up in previous hearings. I think we are all concerned about the effect of the environment on the fish and the birds, but living in Los Angeles I am a little concerned about the effect of smog on human beings and studies of that sort. I wonder if you would not agree that support for investigations in areas of this sort are perhaps at least equally important with research in the problems involving the fish and the birds?

Dr. RIPLEY. I congratulate you, Mr. Brown, because I think you are living in a living laboratory.

Mr. BROWN. I am not sure that congratulations are in order.

I do not have any further questions.

Mr. DADDARIO. Mr. Mosher.

Mr. MOSHER. Mr. Chairman, Dr. Ripley's testimony this morning is very provocative and very demanding and, therefore, very valuable. I am curious about only one detail. On page 5 you say:

> So long as the prohibition against transfers of NSF funds for research in agencies receiving appropriated funds continues in force, the Smithsonian will not receive NSF grants for research projects of individual Smithsonian staff members.

Is that comment in the nature of a criticism or a compliment, Dr. Ripley?

Dr. RIPLEY. No, not at all. It is simply a fact, it is so stated.

Mr. MOSHER. Would it be wise to do away with this prohibition, and whose prohibition is this?

Dr. RIPLEY. This was a prohibition of the Congress.

The Independent Offices Appropriations Act came to this conclusion in 1963.

Mr. MOSHER. This was in the Appropriations Act?

Dr. RIPLEY. Yes. The question came up in connection with the NSF budget, as I recall, before the Appropriations Committee, and the question came up that in view of elimination of possible overlaps, it would be unwise for an agency such as NSF to give grants to individuals within another agency for individual organized research projects, that a member of the Smithsonian's staff embarking on an individual research project which is not budgeted for within the kinds of budgets of the Smithsonian, which merely allow him to hold his position and job there, which he required outside funds of added support for some particular job, that he could not then apply to the NSF for it. We asked for substitute research funds based on an averaging of the last 2 years of the kinds of support that we have been receiving from NSF for original research, and Congress awarded us this sum of money, so that we then have set up, using the NSF as an example, an ad hoc outside panel group to consider applications made by our own scientists for research projects which were beyond their normal salary and budgeting within the Smithsonian.

Mr. MOSHER. And that ad hoc procedure is working fairly well?

Dr. RIPLEY. We have copied exactly the NSF procedure and we are delighted with it because it has I think been an absolutely guaranteed cast iron kind of procedure in which one's own peers are brought in to consider these.

Mr. MOSHER. So you think perhaps the congressional prohibition was wise, at least to your knowledge?

Dr. RIPLEY. After the fact we are perfectly happy about it. We feel we can stand on our own feet, that we do have a reputable and distinguished staff of our own, and when they can go out in a competitive situation in the awarding of grants and receive funds judged on the same kinds of processes, then this is all right. I was concerned at the beginning that, (*a*) we might not receive any research funds through such awarding, and, (*b*) the kinds of procedures which the NSF had set up which were so good might be difficult to achieve in a smaller frame of reference, but I think we have solved it. It is more expensive for us because we have to get the outside panelists and get the people, something that NSF already does.

Mr. MOSHER. No further questions.

Mr. DADDARIO. Mr. Davis.

Mr. DAVIS. Dr. Ripley, I have a question or two on the subject that Mr. Brown brought up, and that is the exchange of scientific and technological information. This is a subject that has continued to pop its head up in our committee hearings ever since I have been on this committee. It is one, I think, of very great importance. As both you and Mr. Brown intimated, there are a number of agencies engaged in that.

The one in the Department of Defense used to be known as ASTIA which I think has changed its name now, there is one in NASA known as STAR. The "S" and "T" standing for "scientific" and "technical" in each. There is quite an effort going on in the Library of Congress in the same realm. Also, private enterprise has put forth a pretty good effort to be a storage house for that information. One of the largest ones is a firm known as Documentation, Inc. I have wondered if the scientific and technical community would not finally come to rest on one or the other of the agencies that I have named as being the one to store information with. In your opinion, are you conversant enough with the other agencies to be able to say that the ball has come to rest on SIE or one of the others?

Dr. RIPLEY. There is a committee known as COSATI, which has to do with the Federal Council for Science and Technology, which I think has been continually examining this problem of science information exchange and its relations to technology, and I would defer to them because they are steeped in this sort of problem. I would be inclined to say that it is probably better to let some of these competing groups, if they are in competition with each other, try their wings and see whether they work or not. I was trying to answer Mr. Brown a little bit along this line but unsuccessfully perhaps. What I really meant was, in a sense I used the phrase, "let the devil take the hindmost," let there be more attempts at this than less, because the problem is one of such urgency, let there be more attempts to collect and interchange information than less, and let them work themselves out.

I do not think that the problem is going to be solved, perhaps, in any other way than by groups trying, either privately or governmentally supported. I would hope that many of the information mechanisms, exchange mechanisms now within agencies related to basic

science and perhaps R. & D., would swing into line and join this group of the SIE supporters. But I would not press for this too hard in terms of the idea that the importance of the total task is such that by attempting to set some limits arbitrarily to the kinds of information exchange experimentation now going on we might damage the information exchange itself.

Mr. DAVIS. It strikes me as being highly desirable that one agency, and perhaps SIE is the logical one, should be thought of as the central storing place. Conceivably, however, it might be possible to link them all together, so if by making an inquiry to SIE you would get the benefit of the facts on hand in the other centers.

Dr. RIPLEY. If this could be done, and I am sure it would be an optimal and utopian situation, if everything could be put on to a coaxial cable, I think everything would be ideal and wonderful. I would be all for it. I would defer to the experts of the COSATI-like committees and adhere to their opinion on the subject.

Mr. DAVIS. That is all.

Mr. DADDARIO. Mr. Roush?

Mr. ROUSH. Mr. Chairman, I merely wanted to ask Dr. Ripley if the social sciences are included in the work of SIE.

Dr. RIPLEY. I believe so.

Mr. ROUSH. Does that include research in the area of criminal behavior?

Dr. RIPLEY. Yes. Would you like me to submit a written answer on the work SIE is doing in the social sciences?

Mr. ROUSH. All right.

(The information referred to is as follows:)

Social and Behavioral Sciences Research Registration Science Information Exchange, July 1965

The Smithsonian Institution's Science Information Exchange (SIE) began in 1949 as a result of Federal agency interest in maintaining a clearinghouse for current research of medical interest from all sources. Since that time the scope of SIE has broadened to include social sciences, as well as the full range of biological and physical sciences, and the Exchange now receives up-to-date information on some 100,000 unclassified proposals, grants, awards, contracts, and projects. Of these, about 70,000 are active research projects, the summaries for which contain detailed information on work in progress or projected. This summary is indexed in whatever depth the description allows by a staff of scientists with backgrounds in the areas covered, allowing retrieval of specific features of interest to the academic and research community.

The focus of coverage remains that of current research activities, and does not include results of research, bibliographies, or reports and reprints from the published literature. SIE supplies information only on demand, concerning studies in progress in specific areas, and issues no regular publications as routine output. Any investigator from a recognized research institution is eligible to ask questions of the system. Some 43,000 requests were processed last year, of which about 5,500 were detailed subject questions. About 1 million notices of research projects were sent out in connection with all types of services.

Input sources for the Exchange include all Federal agencies, State-level programs, research at universities with local support, and major private foundations (about 80). Commercial input to date is limited. Investigators are invited to register on-going research not under support from Federal sources; input in the field of the social sciences is particularly encouraged.

SOCIAL SCIENCES: DEFINITION OF COVERAGE

A compilation of major indexes devoted to the social and behavioral sciences in daily SIE usage has been attached. In the computer tabulation of current research in these areas which has been provided, and in the definitions of index areas which follow, it was not considered useful to distinguish between these two concepts. "Behavioral sciences" as a concept has been broadened in current usage to be fully as comprehensive as "social sciences," including research in the fields of psychology, anthropology, sociology, economics, political science, linguistics, and other areas common to the field usually known as "social sciences." In their applied aspects, behavioral sciences are concerned with practice in such areas as education, mental health, personnel utilization, city planning, communications, and the problems of emerging countries.[1] The Committee on Scientific and Technical Information (COSATI) of the Federal Council on Science and Technology uses a similar grouping of these concepts.[2] In spite of the more biologically oriented aspects of psychology, this field is nevertheless often considered as one of the social sciences.

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[1] This is the sense in which the concept of behavioral sciences is presented by the behavioral sciences subpanel, life sciences panel, President's Science Advisory Committee, "Strengthening the Behavioral Sciences," Apr. 20, 1962, pp. 1 and 2.

[2] COSATI "Subject Category List, Federal Council on Science and Technology, December 1964."

In the index definitions which follow, the broad basis of definition implied by the previous discussion is utilized. Research in psychology, psychiatry, sociology, anthropology, education, and social welfare is included, along with those aspects of economics, political science, history and law which intersect or overlap either with one of these fields or with the fields of medicine or agriculture. Research in economics, political science, history, or law not related to the other areas named has not been considered as falling within our authorized scope of subject matter coverage. The same type of exclusion applies to topics in the COSATI grouping devoted to the humanities and to administration and management. With respect to documentation and information technology, only the communications-related aspects of this field are covered under social sciences indexes; equipment, instrumentation, and systems research is covered elsewhere. All other groupings included in the COSATI subject list (human factors engineering, linguistics, man-machine relationships, personnel selection, training, and evaluation) are included.

SIE INDEXING OF SOCIAL SCIENCES

Fundamentally, a research project is indexed by the SIE staff to as many subject areas as are necessary to adequately describe the conceptual and detailed subject content of the project. In this respect the field of social sciences is indexed in exactly the same manner as is research in biological and physical sciences. The interdisciplinary nature of current research is such that a problem in endocrinology, mathematics, or chemistry may be an integral part of understanding of behavioral and thus social sciences research. A more detailed discussion of the structure and function of SIE indexes is available upon request.

[Attachment No. 1]

RESEARCH IN SOCIAL AND BEHAVIORAL SCIENCES FISCAL YEAR 1964 AND LATER

Grants are recorded by Science Information Exchange (SIE) for the fiscal year in which the work begins.

The grants listed herein for fiscal year 1965 represent only those that have reached and cleared SIE as of July 28, 1965. All records for a fiscal year do not reach SIE until several months after July 1.

"Continued" refers to grants initiated in previous years and have been renewed or continued as new grants for same research problem.

Active grant survey, by agency

	1963			1964			1965			1966		
	New	Continued	Total	New	Continued	Total	New	Continued	Total	New	Continued	Total
Agriculture Department:												
Extramural				24	144	168	36	166	202			
Intramural				8	46	54	8	41	49			
Total				32	190	222	44	207	251			
Commerce Department:												
Bureau of the Census:												
Extramural												
Intramural				3		3	1		1			
Total				3		3	1		1			
Bureau of Public Roads:												
Extramural							27		27			
Intramural												
Total							27		27			
National Bureau of Standards:												
Extramural												
Intramural					2	2	8		8			
Total					2	2	8		8			
Agency total:												
Extramural							27		27			
Intramural				3	2	5	9		9			
Total				3	2	5	36		36			
Defense Department:												
Air Force:												
OAR:												
Extramural				32	86	118	3	17	20			
Intramural					1	1		1	1			
Total				32	87	119	3	18	21			

Systems Command:												
Extramural				36	2	38	2	1	3			
Intramural				147	5	152	4	16	20			
Total				183	7	190	6	17	23			
Agency total:												
Extramural				68	88	156	5	18	23			
Intramural				147	6	153	4	17	21			
Total				215	94	309	9	35	44			
Army:												
AMS, AMR & DC:												
Extramural				28	26	54	1	7	8			
Intramural				13		13						
Total				41	26	67	1	7	8			
ARO:												
Extramural												
Intramural				15	19	34						
Total				15	19	34						
CH R & D, TAGO:												
Extramural				4		4						
Intramural				12	6	18	10	5	15			
Total				16	6	22	10	5	15			
MA/MO/MU/WEA:												
Extramural				1		1	1		1			
Intramural				1		1						
Total				2		2	1		1			
Agency total:												
Extramural				33	26	59	2	7	9			
Intramural				41	25	66	10	5	15			
Total				74	51	125	12	12	24			
Navy:												
BU MED & SUR:												
Extramural												
Intramural				30	20	50	13	31	44			
Total				30	20	50	13	31	44			

Active grant survey, by agency—Continued

	1963			1964			1965			1966		
	New	Continued	Total	New	Continued	Total	New	Continued	Total	New	Continued	Total
Navy—Continued												
BUWEPS, SY & D:												
Extramural				1		1	1		1			
Intramural												
Total				1		1	1		1			
ONR:												
Extramural				64	187	251	22	162	184			
Intramural				5	1	6	5		5			
Total				69	188	257	27	162	189			
Agency total:												
Extramural				65	187	252	23	162	185			
Intramural				35	21	56	18	31	49			
Total				100	208	308	41	193	234			
Health, Welfare, and Education Department:												
BSS:												
Extramural				153	140	293	104	135	239		1	1
Intramural				23	3	26	6	15	21			
Total				176	143	319	110	150	260		1	1
Education:												
Extramural				243	26	269	274	9	283	2		2
Intramural												
Total				243	26	269	274	9	283	2		2
Food and Drug:												
Extramural												
Intramural					1	1						
Total					1	1						

National Institutes of Health:												
Extramural				874	1,472	2,346	536	1,018	1,554			
Intramural				272		272						
Total				1,146	1,472	2,618	536	1,018	1,554			
Social Security Administration:												
Extramural				8	7	15						
Intramural												
Total				8	7	15						
Vocational Rehabilitation Administration:												
Extramural				166	191	357	132	195	327		1	1
Intramural												
Total				166	191	357	132	195	327		1	1
Welfare Administration:												
Extramural				50	48	98	70	24	94			
Intramural												
Total				50	48	98	70	24	94			
Agency total:												
Extramural				1,494	1,884	3,378	1,116	1,381	2,497	2	2	4
Intramural				295	4	299	6	15	21			
Total				1,789	1,888	3,677	1,122	1,396	2,518	2	2	4
Bureau Commercial Fisheries:												
Extramural												
Intramural				12		12		12	12			
Total				12		12		12	12			
Bureau of Sport Fisheries and Wildlife:												
Extramural												
Intramural					10	10	1	3	4			
Total					10	10	1	3	4			
Bureau of Sport Fisheries, Field Activities:												
Extramural				1		1	6		6		1	1
Intramural												
Total				1		1	6		6		1	1

Active grant survey, by agency—Continued

	1963			1964			1965			1966		
	New	Continued	Total	New	Continued	Total	New	Continued	Total	New	Continued	Total
Health, Welfare, and Education Department—Con.												
National Park Service:												
Extramural							6		6			
Intramural												
Total							6		6			
Agency total:												
Extramural				1		1	12		12		1	1
Intramural				12	10	22	1	15	16			
Total				13	10	23	13	15	28		1	1
Labor Department:												
Office of MP, AU, TR:												
Extramural				78	4	82	54	6	60	2		2
Intramural				5		5	4		4			
Total				83	4	87	58	6	64	2		2
Post Office Department												
State Department, AID:												
Extramural				8	5	13	7	2	9			
Intramural												
Total				8	5	13	7	2	9			
Treasury Department												
Atomic Energy Commission, Biology and medicine:												
Extramural				6	8	14	1	5	6			
Intramural				3		3	3		3			
Total				9	8	17	4	5	9			
Federal Aviation Agency:												
Aviation medicine:												
Extramural												
Intramural				26		26						
Total				26		26						
Systems R. & D. Service:												
Extramural							1		1			
Intramural				12		12						
Total				12		12	1		1			

Agency total:												
Extramural							1		1			
Intramural				38		38						
Total				38		38	1		1			
Housing and Home Finance Agency												
National Aeronautics and Space Administration:												
Extramural				37	16	53	5	12	17			
Intramural												
Total				37	16	53	5	12	17			
National Science Foundation:												
Biology and medicine:												
Extramural				71	235	306	57	192	249			
Intramural												
Total				71	235	306	57	192	249			
Engineering:												
Extramural				1	2	3	1	1	2			
Intramural												
Total				1	2	3	1	1	2			
Mathematics and Physics:												
Extramural				3	1	4	2	3	5			
Intramural												
Total				3	1	4	2	3	5			
Office of Antartic:												
Extramural							1		1			
Intramural												
Total							1		1			
Office of Science Information:												
Extramural							2		2			
Intramural												
Total							2		2			
Social Science:												
Extramural				149	91	240	48	43	91			
Intramural												
Total				149	91	240	48	43	91			
Agency total:												
Extramural				224	329	553	111	239	350			
Intramural												
Total				224	329	553	111	239	350			
Small Business Administration												

Active grant survey, by agency—Continued

	1963			1964			1965			1966		
	New	Continued	Total	New	Continued	Total	New	Continued	Total	New	Continued	Total
Smithsonian Institution:												
Extramural												
Intramural							78		78			
Total							78		78			
Tennessee Valley Authority												
Veterans' Administration:												
Extramural												
Intramural				507	1,134	1,641	291	564	855			
Total				507	1,134	1,641	291	564	855			
Federal Communications Commission												
Civil Service Commission												
Foundations and societies:												
Extramural				232	128	360	132	90	222	1	1	2
Intramural												
Total				232	128	360	132	90	222	1	1	2
Universities:												
Extramural				17		17	30	1	31	1		1
Intramural												
Total				17		17	30	1	31	1		1
State and local agencies:												
Extramural				104	171	275	66	143	209		1	1
Intramural												
Total				104	171	275	66	143	209		1	1
Private industry:												
Designated:												
Extramural				13	20	33	12	4	16			
Intramural												
Total				13	20	33	12	4	16			

Nonsupported:												
Extramural				1		1	7		7			
Intramural												
Total				1		1	7		7			
Grand total:												
Extramural				2,405	3,010	5,415	1,647	2,236	3,883	6	5	11
Intramural				1,094	1,248	2,342	432	688	1,120			
Total				3,499	4,258	7,757	2,079	2,924	5,003	6	5	11

Current SIE Activities in the Social and Behavioral Sciences

1. GENERAL

In 1964 the Exchange was represented at interagency discussions of the Panel on Behavioral Sciences of the Federal Council on Science and Technology. In the course of a series of meetings, each Federal agency presented a discussion of its general level of support of social science research. There was considerable attention given to delineation of the areas concerned, and it became apparent in the emphasis given to current research in economics that the concepts of behaviorial and social sciences were in effect interchangeable. At that time some of the agencies represented requested computer listings of behavioral science research from the Exchange, but no systematic or comprehensive followup resulted.

Current SIE coverage of Federal agency activities in the social and behavioral sciences has in the past been estimated to be about 95 percent complete. With the advent of multi-million-dollar activity in research and community demonstration projects dealing with poverty, education, and public welfare, it will be necessary to insure that mechanisms for comprehensive registration of these programs are established (see below).

2. PSYCHOLOGY

(*a*) *American Psychological Association*

Discussions have been held with members of the APA staff concerning current research in psychology, and corncerning the nature and extent of coverage of SIE in the field of psychology. A survey was made of the use of the Exchange by psychologists; over 25 percent of life and social sciences requests come from members of the APA.

It is anticipated that an SIE exhibit or a distribution of SIE literature will be included in the 1965 APA Convention arrangements.

(*b*) *New York State Psychological Association*

During 1965 a cooperative program is being undertaken with the New York State Psychological Association which may well serve as a model or prototype for further cooperative efforts with State psychological associations. This association had been collecting research projects in progress being done by its membership; they have undertaken to collect at the same time a description for SIE registration. Many sources of State and local support not now covered by the Exchange should be included in this manner.

3. SOCIOLOGY

At a local meeting of the Columbia Sociological Society in May 1964 it was ascertained that none of the sociologists contacted knew about the existence of the Exchange. Dr. Gresham Sykes, executive officer of the American Sociological Association, was then contacted and a meeting was held July 23. It was agreed that SIE would be represented at the meeting of the American Sociological Association in Montreal (August 31 to September 3) and that a brochure describing SIE would be distributed through the registration desk to all participants. After the meeting another conference was held with Dr. Sykes and it was agreed that SIE undertake a direct mailing to the entire membership of the ASA (8,000) requesting them to register on-going research projects. The mailing campaign was carried out during the months of February and March and resulted in registration of about 200 new non-Federal projects and about 50 subject inquiries. Dr. Norman Kaplan, associate professor of sociology, University of Pennsylvania, whose field is the sociology of science, approached the Exchange with the intent to use the input from the mailing campaign for a number of surveys of the on-going research in the field of sociology.

4. ANTHROPOLOGY

A first conference to explore cooperation between SIE and anthropologists to extend coverage was held on August 12 with Dr. Steven Boggs, executive secretary of the American Anthropological Association, and Dr. Gordon Gibbs, Cultural Anthropology of the Smithsonian Institution. Dr. Boggs expressed interest but said he would prefer to wait for the results of the pilot program wih the ASA. A second meeting was attended by Dr. Boggs and Dr. Sol Tax, editor of "Current Anthropology" in spring 1965. Drs. Boggs and Tax promised to investigate which approach would yield the best results in obtaining registration especially of unfunded or intramural and individual research.

5. MANPOWER

During a conference held January 6, 1965, with Mr. J. Katz and Mr. G. E. Donahue of the Office of Manpower and Automation (OMAT) it was agreed that SIE would be the central clearinghouse for OMAT and that OMAT would make any sources of research in the field of labor automation and its consequences known to SIE.

6. POLITICAL SCIENCES

Dr. W. E. Miller, executive director of the Inter-University Consortium for Political Research, contacted SIE on June 17, 1965, and suggested that political sciences research be included in the coverage of SIE. A computer run showed that about 50 projects involving political scientists are registered with SIE now. Registration of the projects going on at the Inter-University Consortium is being considered now.

7. URBAN RESEARCH

Dr. Scott Keyes, editor of the "Research Digest" issued by the Bureau of Community Planning of the University of Illinois approached SIE in order to obtain all projects on urban and regional planning now registered with SIE. It was agreed to arrange that SIE would register all projects listed in the "Research Digest" which had not been previously incorporated. In September 1964, SIE was proposed as a clearinghouse for urban research and an index was created for this purpose at that time.

8. WELFARE

In November 1964, the Bureau of Family Services of the Welfare Administration, HEW, requested the assistance of the Exchange in a projected publication, "Research and Demonstration Relating to Public Welfare." Inasmuch as the primary requirement was for professional staff assistance in the generation of a subject index to this current research, the Exchange was able to devote the necessary time (about 3 man-months) without charge to the Welfare Administration. This effort was completed in April 1965, and a letter from Mr. Fred H. Steininger, Director, Bureau of Family Services, is attached.

A special index devoted to the coverage of the field of social welfare was generated in August of 1964 in anticipation of the developing Federal interest in this field.

9. OFFICE OF ECONOMIC OPPORTUNITY

Contact has been made (June 1965) with the Office of Economic Opportunity, Office of Research, Plans, Programs, and Evaluation, to arrange for the registration of the newly funded programs of this agency. These programs are now reaching a point at which it is possible to talk in terms of registration of specific projects. There are three types of research and demonstration projects involved: (1) intramural, carried out by personnel of the Office of Economic Opportunity, (2) extramural, consisting of contracts awarded by OEO to external research groups, and (3) delegated programs, consisting of awards to other Federal agencies for the conduct of research and demonstration projects in their particular subject area. Miss Carole McCarthy of this group is attempting to arrange for an SIE notice of research project form to be included and completed with every contract award, and has requested and received a supply of NRP forms for registration of intramural projects. She recommends contact with recipient Federal agencies in the case of delegated programs inasmuch as the several agencies will allot the expenditure of funds for particular projects.

10. OFFICE OF EDUCATION

It is anticipated that large-scale fund expenditure for research will be increasingly available in the Office of Education, partly due to the tie-in with the current interest in positive activities for overcoming poverty. New programs are being funded in the education of handicapped children and in vocational and technical education, and arrangements have been made for this input of research and demonstration projects in these areas. Subject searches are being made on research proposals from the vocational and technical education program.

A development research and demonstration center program of the cooperative research program has been registered through its coordinator, Dr. Ward S. Mason.

The Educational Research Information Center of the Division of Educational Research, under Dr. Harold Haswell, has arranged for close cooperation with the exchange in the registration of research activities; during the past year there was exploration of ways in which the exchange could be of most value to the informational and other programs of the division.

11. OTHER LINES OF ACTIVITY

Contact has been made with the National Council on Crime and Delinquency with respect to their activities in the collection of current research projects in this field. It is possible that projects covered in their publications which are not already registered with the exchange can be registered, and it is anticipated that this contract will be renewed shortly.

Similarly, the Health Information Foundation maintains "An Inventory of Social and Economic Research in Health"; some of these projects are not as yet registered with SIE, and it should be possible to arrange for such registration. This is being pursued.

Finally, the exchange cooperates with various Federal agency information activities not covered above, by providing notices of research projects in the area concerned. An example of this would be the Clearinghouse for Research on Children of the Children's Bureau, Health, Education, and Welfare.

Future Goals of Science Information Exchange (SIE) in Social Science Research

The overall direction of Science Information Exchange (SIE) development should be first toward a comprehensive national inventory of currently active research in basic and applied areas. Since modern research is significantly interdisciplinary, a useful inventory must cover all fields of scientific research, literally from astronomy to zoology.

To cover this broad multidisciplinary spectrum of subject fields on a national scale is, indeed, a formidable task; but only because the collection of timely information from thousands of independent sources is a slow, tedious, and time-consuming process at best. SIE has developed the techniques, methodology, and machinery to do this job. Given time and increasing cooperation from all segments of the scientific community, the job can be done without extraordinary expansion or costs.

The progress toward this goal has lately been most encouraging in the social sciences. For some years our primary target was a comprehensive collection of Federal Government research. We believe that 95 percent of all on-going work in social sciences from these sources is now in hand. For several years the major target has been the private foundations and fundraising agencies that support research in the social sciences. About 80 of the largest are now actively cooperating with SIE and more are being added as fast as SIE manpower and resources can ascertain their identification and engage their participation. However, there are estimated to be 5,000 to 10,000 nonprofit organizations, both large and small, supporting some kind of research throughout the Nation. To identify all of these and to establish smooth-working exchange realtionships with each takes considerable time.

Within the past 2 or 3 years, SIE has also established cooperative arrangements with many State and local government agencies that support or conduct research on some phases of the social sciences. Now that the largest collections, Federal and private foundations, are well in hand SIE will place major emphasis on expanding its collection and services throughout the State and city government agencies.

Other important sources of research information and cooperative exchange are the universities that support and carry out substantial research programs with their own funds, local gifts, grants, and contracts. A number of universities have agreed to participate in the SIE program and we are now redoubling our efforts to reach many more of the hundreds of universities and colleges that are also potential sources.

As noted elsewhere in this report, we have been especially encouraged and have made significant advances toward a comprehensive inventory in social sciences through the interest and cooperation by professional societies, by other associations, and consortia that are primarily concerned with social sciences research.

While SIE is, of course, attempting to advance its coverage on all fronts of basic and applied research, progress in the social sciences, as described above, has been particularly encouraging. On this basis, we would hope to approach a comprehensive national inventory within a few years.

When the approach to this goal is evident, it will be feasible to contemplate the exchange of this kind of information on an international basis.

Scientific research does not recognize international boundaries, and the consideration of an international exchange system advises caution only because of the titanic nature of the task. It would seem reckless to prematurely attempt operations on such a scale without experience, practical techniques, and sound methods that have to be tested and proven on the scale of a national program.

An international exchange system could be practical and feasible at this point, if confined to a reasonable level of effort and scope, and if it were to be approached as a pilot plant test model.

If SIE progress in the social sciences (and in one or two other specialized areas) continues as favorably as it has in the past year, it may soon be the time to consider an international system in a selected area such as the social sciences.

Mr. DADDARIO. Dr. Ripley, you mention the Elliott Committee's endorsement of SIE. Yet, as I recall the Elliott Committee report, it said that the support and use of SIE left something to be desired. Can you give us some idea of what they were referring to in that regard?

Dr. RIPLEY. My impression, Mr. Chairman, was what they were referring to was this matter of input and feedback that I have tried to refer to. As a matter of fact, agencies concerned with information exchange and preparation of reports on current research were not fully prepared to cooperate with the SIE in the beginning. The result of their perhaps reluctance, which may have been for reasons of security and things of that sort, was that as they did not collaborate with the SIE, they saw less and less use for it, it began to drift away from them. This is a very current operation. So as they sort of stood back and were reserved and only gave just partial or token support to the concept, they began to lose track of it, and in this sense it is vitally important that the more one puts in as an agency, the more end use one gets out of the facility. This I think is the nub of this problem. I think that this is being partially solved since the Elliott Committee report came out in greater thrust toward this COSATI overseeing of the agency's activities and attempt to urge more forceably and more strongly all of the participating groups to get into the act, as it were, and start feeding current information in, and the instant they do this, they become quite enthusiastic about it. So it is a process of education, almost missionary-like, going on with some of the cooperating agencies.

Mr. DADDARIO. I regret we do not have more time. We have a quorum call now on the floor of the House.

I wish to apologize to Dr. Bates; I had hoped we could continue. I understand we have an open date, and I hope we might be able to reschedule your testimony, Dr. Bates.

Would you discuss that with Dr. Bates, Mr. Yeager?

We have a whole series of questions, Dr. Ripley, which we like to submit to you so they may be answered for the record.[1] I had wanted you to go into depth on this idea that you have mentioned on page 19, where you said "to preserve him and meet the challenges of constant change."

I think there is more to widening the base and developing knowledge than to just get along in this world, and we quite agree that preserving ourselves, as ominous as that may sound, is something we should keep in mind.

I did hope to get into the idea, too, of having more information about cultures which are escaping us, and some of the animals of this world that are disappearing. I know you have been engaged in the question involving the blue whale. This has a great deal of importance, and I believe that we ought to have more information on these programs. I am sorry we have not had a chance to get into it here, but we can handle it in this other way. We will try to get the questions to you as soon as possible.

I want to thank you for a most informative morning.

The committee will adjourn until Tuesday, next, at 10 o'clock at this same place.

(Whereupon, at 11:35 a.m., the subcommittee was adjourned to reconvene at 10 a.m., Tuesday, July 27, 1965.)

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[1] The questions referred to, and the witness' response thereto, will be contained in Volume II of these hearings.

NATIONAL SCIENCE FOUNDATION

TUESDAY, JULY 27, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m. in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario, (chairman of the subcommittee), presiding.

Mr. DADDARIO. This meeting will come to order.

Our first witness is Dr. Eric Walker, who is the Chairman of the National Science Board and, therefore, directly involved with the scope of these hearings on the National Science Foundation. Dr. Walker is also the president of the Pennsylvania State University.

We are pleased to have you with us this morning, Dr. Walker.

STATEMENT OF DR. ERIC A. WALKER, CHAIRMAN OF THE NATIONAL SCIENCE BOARD, AND PRESIDENT, PENNSYLVANIA STATE UNIVERSITY

Dr. WALKER. Mr. Chairman and members of the subcommittee, I appreciate this opportunity to appear before you and to comment on three matters concerning the National Science Foundation which I think are of considerable interest. The first is the problem of responsibility and control. The second one is the distribution of funds. And the third one is the engineering problem.

I have read a great deal of the testimony that has been given before this committee, and therefore I will do my best not to repeat what you have already been told.

The first matter I would like to touch upon concerns the question of responsibility and control. I am sure that some of you remember that when the original proposal to create the Foundation was under consideration in the Congress, this matter of responsibility and control was the subject of considerable discussion. When the first bill to establish the Foundation was sent to President Truman in 1947, he vetoed it on the grounds that the organization as then envisaged would be "divorced from the control of the American people," and that neither the Board nor the Director could be held responsible by the President or by Congress for "the determination of vital national policy, the expenditures of large funds, and the administration of important Government functions." And then the act of 1950, under which the Foundation was finally established, was designed to

overcome these objections, and with subsequent modifications, has in my opinion provided a base on which the progress of science and scientific research in this country can be prudently controlled by all parties who should bear responsibility for the proper functioning of such a large and complex enterprise.

The responsibility of the Foundation to the Congress is emphasized through the appropriations, and it is properly maintained by the appropriate budget hearings and hearings such as the one that is being held today before this subcommittee. Responsibility to the administration is effected through the Director of the Foundation, the science adviser to the President, and also through the Bureau of the Budget.

Responsibility to the scientific community is no less important, but it is much more difficult to manage in a clear-cut manner. It is through the Board and through various panels which the Board has created that this area of responsibility must be continually maintained, and the judgments that have to be made in this connection are never made very easily.

The very nature of scientific relationships in this country poses difficulties. As far as the Foundation is concerned, the only practical way to get a competent judgment on the technical value of a research proposal, for example, or on the qualifications of a fellowship grantee, is to rely on the opinions of people who are well versed in the area of science under consideration, or who are qualified by expert knowledge to judge the merits of the individual involved.

This means that we are not infrequently finding ourselves in the position of asking a man to judge the proposal of his friend. The danger inherent in this practice, I think, is pretty obvious. Yet on the other hand we feel it is essential that if the operations of the Foundation are to be wisely managed and the basic goals of the Foundation are to be achieved, this can only be accomplished by having the Board and its panels made up of people who have some acquaintance with scientific matters and some reputation among scientists.

The activities of the Foundation can be effective only if there is a close and strong coupling between the Foundation and the scientific community. The problem is that the Board has a great deal of difficulty making this coupling a useful one.

Changes from time to time in the internal structure of the Foundation, and the several formal reorganization plans, have been aimed, among other things, at strengthening this coupling. The most recent reorganization scheme, which abolished the legal requirement for certain divisional committees, is intended to create greater flexibility in the Foundation's operations as far as the relations with the scientific community are concerned, but whether under the new arrangements the divisional committees will have greater or lesser impact on the operations of the division still remains to be seen.

Now all of this brings me to the major point I want to make in regard to the workings of the Board. The act setting up the Foundation spells out the responsibilities of the Board. In fact, most of the responsibilities for planning, setting policies, and even operations, reside with the Board unless it delegates them to the Director. But I

must emphasize one point: The Board may delegate authority but not responsibility.

The Board, as the Foundation's business has grown, has found it necessary to give the Director authority to fund projects up to certain dollar limits, to continue and expand established programs and to perform other acts in the name of the Board. But the responsibility for the consequences of these decisions still rests with the Board.

Moreover, the Board cannot delegate its responsibility for establishing general plans for the Foundation, deciding in which direction the Foundation should go, and making the larger decisions in which the Director needs the specific support of the Board.

Now all of this takes a great deal of time and effort and it places on the shoulders of the Board a burden which has become much greater as the Foundation has grown from a million-dollar-a-year operation to one approaching half a billion dollars a year.

Now within the past 2 years the Board has reorganized itself to better handle this task. It has established three committees: one dealing with the balance of effort at the present time; one looking toward what ought to be done in the future, say 5 years from now; and one which deals with the current administrative problems of the Board. Each member serves on one of these three committees, which are now meeting on a schedule of approximately 1 day a month. In addition, the members attend the usual Board meetings, which in the past have been held about seven times a year with each meeting being scheduled for 2 or 3 days.

But this isn't enough. There is still too much to do. As the Foundation grows, new ways will have to be found for the Board to maintain its effectiveness in the policymaking functions if it is to keep abreast of the expanding operations.

How this can be done I really don't know, and I must be frank to say that I have not yet discussed this matter with anyone but Board members, and not even the Director. What I am offering here are my own unrefined ideas.

But it seems to me that possibly some of the devices and management methods which are generally used in our large corporations might be applicable to the Foundation. For one thing, I think that the duties of the Board could be more effectively carried out if the Board itself had its own small staff of full-time people—possibly one staff member for each of the Board's committees. These people should be of high enough caliber to be able to put together a policy paper based on informal studies for the committee to discuss for possible recommendation to the Board.

In order to maintain a clear separation between policymaking and operations, which I believe is imperative, these people should not be normally members of the Foundation's staff, closely associated with the operating functions of the Foundation. They must be staff to the Board.

This sort of thing is the practice in many corporations and it might well be effective in helping the Board to keep abreast of its increasingly heavy duties. I feel too that the time is approaching when it might be desirable to have a full-time Chairman of the Board. This might make it possible to have a logical separation between policy-

making and the management of the program of the Foundation, with the Board Chairman being "Mr. Outside" establishing policies, representing the Foundation in the scientific community and among other agencies of the Government, while the Director himself would be "Mr. Inside" with full-time responsibility for the management of the operations.

As you know, this sort of thing, too, is done in industry, where many large corporations have both a full-time chairman of the board and a full-time president. In fact, this pattern now seems to have some acceptance in university circles, for the Massachusetts Institute of Technology now has a full-time chairman and a full-time president.

I might add parenthetically that this might be done quite easily by having the present Director assume the duties as Chairman, and having the Deputy Director run the program.

But certainly something must be done to enable the Board to carry out its policymaking functions more effectively and with greater dispatch. The answer is not clear-cut to me, but perhaps the wisdom of this committee might help in the solution of the situation.

Mr. DADDARIO. Dr. Walker, you referred to the fact that the Board has given up some of its authority but not its responsibility over the course of time. Therefore it has worked back to the point where the Director carries a greater load. Is it your feeling that during this period of time that the type of recommendation, which you now are making, might have been a better solution than to have removed from the Board some of its authority and responsibilities which it originally had?

How do you see this whole process?

Dr. WALKER. I really don't see it clearly, Mr. Chairman, because the growth of the Board, the Foundation, and its responsibilities and the amount of money it has had to spend, has been a gradual one, from $250,000, or whatever it was, to now almost $500 million a year. I do not think you could ever put your finger on a point to say this is where a great change ought to have been made.

Every year the Board has found it necessary to delegate more and more responsibility to the Director. If we didn't do this, things wouldn't get done. I feel the burden on the Director's shoulders must almost be unbearable, and somewhere or other I think he has had to get some help in doing these things.

Let me say I have not talked this over with the Director, but I am confident this is true.

Mr. DADDARIO. It might be helpful if you could give us some idea of how the workload of the Board grew to the point where it was not able to function as it should—you used the words, I think: "This is not enough." When did the burden begin bothering you to the point that you began thinking about how the Board might fulfill its function in a more proper way?

Dr. WALKER. Mr. Chairman, you must remember I have been on the Board just over 4 years, and when I came on the Board I was convinced that there were more things to be known than I could learn about. But if you look at the history of the Board, you see that in the early days the only thing they had to do was to grant fellowships and basic research contracts. Then we started adding such things as the science information job, which you will hear about later, the in-house

laboratories, the educational development programs, and so on. The work of the Board has grown almost like an inverted pyramid, and sometime in this growth I think it became impossible for the Board to follow everything, certainly to follow anything in great detail.

I do not think we have really examined the responsibilities and the capabilities of a part-time Board such as this.

Mr. DADDARIO. You indicate that the formation of a staff of this kind would present an opportunity to have additional staff help for the Board, separate and apart really from the help that is given to you now by the Director through his staff. If this burden has grown, so far as the Board is concerned, then the burden has also grown on the Director. From that point down through the whole National Science Foundation these stresses and strains must be considered as a problem in the performance of the functions which are intended for the National Science Foundation.

I get the feeling, as you mention your recommendations, that this is something about which this committee ought to be considering and concerned.

Dr. WALKER. Let me say, Mr. Chairman, that I have a firm conviction, and perhaps a prejudice, that when a company or an organization gets to be above a certain size, which I think the National Science Foundation has now passed, that you must have a clear-cut separation between policymaking and operations. I think that the Board ought to turn its attention solely to policymaking, and that whoever is running the show ought to be clearly responsible for the operations. I know this is not well spelled out, and I am unable, in this short time, to offer any good suggestions as to how it can be spelled out, but I think it ought to be.

Mr. DADDARIO. Under the reorganization plan, will this new arrangement involving the divisional committees have greater or lesser impact on the NSF's operations. Do you have some concern about it?

Dr. WALKER. I have some concern about it, sir, because I think the divisional committees are one of the couplings that the Board has with the scientific community. Yet I fail to see how the Board has armed itself to take advantage of the recommendations and the knowledge of these divisional committees. I would hope that if we did have a full-time staff that we could use them in trying to grind the opinions, hopes, and recommendations of the divisional committees into the actions of the Board.

Mr. DADDARIO. Then you see no particular conflict that might arise as a result of the formation of such a Board staff, in contrast to the work being done by the Director and his staff?

Dr. WALKER. Well, this always poses difficulty. There is always the problem of the people in the head office interfering with the people who are running the show, whether it is in a university or in a large industry. But I think the proposal I suggest has been proven in the past, sir. You would have to tell the staff to keep their noses out of the operations, and that their problem was finding out about helping to set policy.

I think this can be done.

There is also the problem that if you have a full-time director and a full-time chairman of the board, they would have to be compatible people. This is one of the reasons I made the suggestion I did, because I think the two people I mentioned are compatible people and can get along under a working arrangement like this.

Mr. BROWN. Mr. Chairman?

Mr. DADDARIO. Yes?

Mr. BROWN. Can I ask a question or two along that same line?

Mr. DADDARIO. Certainly.

Mr. BROWN. Is your point that in order to make the change which you are suggesting and establish a small staff for the Board, that this requires legislative action? Is this outside the powers of the President?

Dr. WALKER. I couldn't answer that question, sir. I don't believe it does require legislative action, but I do not know.

Mr. BROWN. It seems to me that it should be within the powers of the Board if in its wisdom it feels it needs a staff that it should establish a secretariat to the Board which could be insulated to whatever degree may be necessary from operations. It is fairly common for boards to have this kind of staff for their own purposes. I would think, subject to review by legal analysts, that this would be feasible to do at such time the Board itself feels it is desirable.

I am concerned about the emphasis which you place upon the separation of policy and operations. Of course, it is the function of the Board to establish policy, but it is impossible to completely separate policy functions and operations because, after all, the policy relates to the operations. It is necessary for you to be fully informed as to the operations in order to properly develop policy.

Dr. WALKER. You cannot completely separate the two, but you don't want to establish policy in terms of today's problems. You want to establish policy in terms of long-run problems. I think this is why industry usually finds it desirable to have a staff to set the general policies of the corporation, separate from the people who are running the show.

Mr. BROWN. Yes; this is true, but I think if we were to ask the Director, I would suspect that somewhere in the Director's staff he would have a group concerned with long-range policy and rather divorced from current operations. Again, this is typical of progressive managements. They all have this kind of staff available, to the degree which the Board desires it, the resources of a policy planning staff separate from operations could and should be made available to it at the present time.

Dr. WALKER. Yes, Mr. Brown; this does exist. There is a planning staff in the Board's staff, under the Director. I think the problem, as I see it, is that there is not close enough coupling between this staff and the Board proper, and this may be the Board's fault.

Mr. BROWN. Yes; this is something that we need to be informed of as a committee, and which the Board, itself, needs to continue to analyze, I am sure.

No further questions.

Mr. DADDARIO. Will you proceed, please, Dr. Walker?

Dr. WALKER. One of the problems which I know this committee has been concerned about, and one of the problems which the Foundation faces is the uneven distribution of funds granted by the Foundation and their apparent concentration, I say "apparent" concentration, in a few colleges in New England and on the west coast. I have little to add on this problem. We are all aware of the situation. I think some of us deplore it. But the reasons for it are really very complex, and I think there is no simple answer to it. In my opinion, one of the main causes of this condition can be found in a kind of spiraling situation which has no beginning and no end but has as part of it the simple fact that the schools that pay the highest salaries to their faculties are the ones that get the most Federal business. One has only to look at the information published by the Office of Education to verify that fact. By paying the highest salaries they get the best people. Having the best people, they put in the best proposals. These proposals have a higher percentage of acceptance by the Federal agencies that grant the funds. And so these schools get a higher percentage of the grants that are awarded, and at a higher price. And since the price is high, they can continue to pay higher salaries, attract better people, and continue to submit the best proposals.

I know of no simple cure for this situation. It is very difficult and I think quite undesirable to try to fight excellence. This is a case where it is hard to weed out the fault without eradicating the virtue.

On the other hand, of course, we are conscious of the need for more widespread distribution of support for research and for the fuller development of the Nation's potential for scientific activity. Yet, even here, we must not forget that it is from the institutions which are presently the strongest that the men must come who can lead the way in the improvement of the others.

In the meantime, however, in order to accelerate the process, the Foundation has undertaken several programs designed to help correct this situation, which I might repeat to you here.

The first of these are the science initiation grants, which provide support for promising young people who are starting off in colleges where there is relatively little research being conducted.

Another is the institutional grant program, under which the colleges and the universities are granted funds beyond those made available for special-purpose programs—funds which the institution may use flexibly to blend and balance its activities and to strengthen its weak spots. The amount of these funds which an institution may receive is determined by a tapered formula which favors the small school that does not have very many special-purpose grants.

The third program, the science development program, is especially designed to increase the number of colleges of recognized excellence in research and education through the broad and quick upgrading of selected schools and universities, those which show a potential for real improvement. Such schools may apply for relatively large unrestricted grants which may be used to strengthen a single science activity, a group of related activities, or the entire science program of the institution.

Through these three programs, we hope to be able to broaden the distribution of funds awarded and provide more balanced support among

the Nation's campuses. The only other way I could think of to do this would be to put a top limit on the percentage of a university's funds which could come from the Federal Government. I would not advocate such a step under present circumstances, but unless over a period of years the situation starts to correct itself under the current regulations and practices, certainly some new rules would be in order.

I would like to make a few comments about the NSF and engineering. In order to be able to speak frankly, I would like to remove my hat as the Chairman of the National Science Board and to resume my former one as the president of the Engineers' Joint Council.

A good many engineers have felt for some time that engineering has not received proper recognition from the National Science Foundation. There are some of us who remember that during the forming days of the Foundation we tried to have it called the National Research and Engineering Foundation. We were eventually willing to settle for the word "science" when we were assured by definition it would include engineering. But it is pretty clear that engineering, although it has been accepted as a member of the family, has been in some respects treated as kind of a stepsister to the basic sciences.

I think there is some lack of understanding of the true nature of engineering in any government, and indeed in engineering educational circles. I would sum it up by saying that engineering is not analysis; it is synthesis. Engineering is not the accumulation of new knowledge, but it is the process of using knowledge together with money, manpower, and materials to produce instruments which satisfy human needs. And in this process, trial devices and systems must be built and tested. In our economy the engineering process works very well as long as someone can make a profit out of the device or system that is being created and sold. Television sets, washing machines, and airplanes get engineered. But there are many devices and systems the country needs where there is no immediate dollar profit and where no single industry, and certainly no single company has a major interest. This is where, in my opinion, the Federal Government might finance and support the necessary engineering design and test, and such test programs are going to be very expensive.

Mr. MILLER. Doctor, could you give us an example of one of these programs?

Dr. WALKER. I am going to give you some. If I don't give you a good one——

Mr. MILLER. I am very much interested in this, as you know.

Dr. WALKER. There are people who say that all of the engineering required for eventual production can and should be done on paper, after the basic research has been done—without recourse to the test of trial models. But let me point out this is not the way things are best done—or usually done—in other fields.

We have theoretical physicists who work on the theory of high energy physics and who predict with pencil and paper just what will happen when so and so is done. But when they have completed their predictions, they feel compelled to build a high energy accelerator in order to determine if what they predicted really does occur. And we are willing to spend 10 or many more million dollars on such an accelerator. Yet there are many practical needs in society today which could be filled by engineering systems and devices, and for some reason we

seem to be unwilling to spend anything like this amount in designing them and subsequently building engineering models for test purposes.

It seems to me a little incongruous in this day of technology to have a postman visit your house or your office once or twice a day to deliver your mail, when it might be done more efficiently somewhat the same way we deliver gas or electricity. But who can design and test a new system like this? And what about the transportation problem? Who is going to design and test the new systems by which we move from the home to the office and back to the home again?

Let me take as an example the important problem of water retrieval. This is one of the problems on which proposals have already been made, asking the Federal Government to finance new systems. In an area of this sort, of course, a great deal can be done with pencil and paper. But there are questions here that require experimental engineering.

We all know that our streams are becoming polluted, that the detergents we use and wash down the drain are producing certain nutrients in the water that grow vegetation which chokes the streams with weeds. We also know that this effluent is an excellent fertilizer and it can perhaps be sprayed on our fields—as a way of getting rid of it, as a way of improving our crops, and as a way of recovering the water. But if one starts a program using this effluent for fertilizer, there are many things to worry about. What are the effects going to be on the insect population, and on the wildlife? Is it really going to fertilize the land, or poison it? What is going to happen as the water seeps down through the ground? How far will it have to seep before the detergents are broken up, chemically broken up? What happens when the downcoming water hits the water table? Will it provide a proper source for recharging the ground water supplies? And so on.

Obviously the testing out of a system like this is a large-scale engineering project. The proposal for such a project was once submitted to the National Science Foundation and was considered as not being basic research. Of course, it isn't the kind of research we are accustomed to support in physics, chemistry, math, and so on. I might say if I had been on the staff, I would have turned it down as a proposal to the National Science Foundation. Yet, it seems to me this is a most fundamental and useful type of research. And if it is, where in the country is it going to be supported? The Department of Commerce? The Department of Interior? The National Institutes of Health? Or where?

Mr. Chairman, it seems to me there are many large engineering projects which need to have research done on them and which need to be put into shape so that cities, municipalities, States, and even the Federal Government can use them and the people can profit by them. It seems to me that the National Science Foundation might well use some of the Federal funds with which it is entrusted to support such projects. This is a policy decision which might need specific congressional approval. The question should be posed and the answer should be given.

All of this returns me to my original point. There is much work for the Board of the Foundation, and I am not certain the Board is equipped to do this work.

Thank you, Mr. Chairman.

Mr. DADDARIO. Do you have a question along that line, Mr. Chairman?

Mr. MILLER. I think the doctor answered the questions I had in mind.

I want to congratulate you on this, because it is something this committee is concerned with, and we hope to start some hearings on this very shortly, under Mr. Daddario, in the next phase of his work.

I believe that here is where we are completely missing the opportunity to serve the future, and one that we must fulfill. I could point out to you that 17,000 acres of very fertile land in the San Joaquin Valley in California have been so saturated with chemical fertilizers and pesticides that it practically has to be taken out of use. This is a resource we can't lose.

I could go on with some other examples that have come about, the fact that the pesticides that are used on boll weevil in the Mississippi Valley also have a great affinity for the shell fish in the Gulf of Mexico. How do you balance these out? How do we correct them?

With the population burden that the future holds, if we don't start looking at these things now, it will be too late not too many years from now.

Thank you.

Mr. DADDARIO. Mr. Mosher?

Mr. MOSHER. Dr. Walker, what about the present size of the Board, itself? Should it be larger or smaller?

Dr. WALKER. I don't think it has any real impact, Mr. Mosher. Let me say the Board members do work hard, and most of them—by "most" I mean 21 out of 24—attend the meetings regularly. But how a part-time group can get hold of these problems and do the job with which it is charged is something I don't see clearly.

Mr. MOSHER. Is it 25 members?

Dr. WALKER. Twenty-five, counting the Director, as a member.

Mr. MOSHER. If each one had a full-time staff person, that would be quite a large policymaking staff.

Dr. WALKER. Oh, yes.

Mr. DADDARIO. You were not talking about each member having a staff. You were talking about it in relationship to size, weren't you?

Dr. WALKER. I was talking about each committee. There are three committees.

Mr. MOSHER. I got the impression that each member would have one.

Dr. WALKER. I hope not, sir.

Mr. MOSHER. That seemed a little large.

Dr. WALKER. I might say, Mr. Daddario, I make these suggestions mostly because I am discontented with the operations of the Board. I don't feel we are doing as good a job as we should do, and in making these suggestions I am simply throwing them out, hoping that with your wisdom and other people's wisdom, perhaps we can come up with a solution to this, which I think is a most important problem facing the country.

Mr. DADDARIO. We recognize it in that vein, Dr. Walker. We are appreciative of the suggestions and the fact that it does give us an opportunity to measure and match them in accordance with what has been said by other witnesses, and what we see the National Science Foundation doing.

Mr. Roush.

Mr. ROUSH. Dr. Walker, I have been very much aware of the fact that the Board is conscious of the need of an equitable distribution of research funds. I think the Foundation has done an excellent job in the distribution of its own funds. I have wondered, however, if it couldn't do a better job in leading the way and stressing to other governmental agencies the need for distribution of their research and development funds.

Is there a definite relationship between the excellence of institutions located in a certain area and the distribution of Federal research funds, particularly that which goes to industry?

Dr. WALKER. I think that is two questions, Mr. Roush. First, we are talking about the distribution of Federal funds to the universities. I would say that there are even more compelling reasons for, let's say, the Department of Defense to pick out the best universities because the people in the Department of Defense are trying to get the most for the Government's money. If you want to get the most for your money, you go to where the best people are. Then, obviously, industry tends to settle around the good universities. They can use the university staffs for consulting purposes; they can get the graduate students; it is the climate in which this kind of person wants to live; and I think you can point to numerous examples where industry has gone to where the good universities are.

Mr. ROUSH. What has the Foundation done in response to the 1960 report of the President's Scientific Advisory Committee, which advocated additional centers of academic excellence?

Dr. WALKER. Well, it has started on the program which I did mention of trying to pick out a group of schools that have the potential for becoming first class, and grant them large grants of money, hoping to move them up from where they are to being first-class universities. This program has just gotten off the ground, but I have high hopes for it, and it is moving very fast. Ten grants have already been made.

The results of this will be some 5 years in coming, but I think the Foundation has moved very fast on this.

Mr. ROUSH. Now back to my first question, and reversing it, does the distribution of research funds to industry by any of the many governmental agencies affect the distribution of funds to institutions on the part of the Foundation? In other words, in developing centers of excellence, are you in any way persuaded by the existence of research and development in a certain area?

Dr. WALKER. I don't think so, sir.

Mr. ROUSH. Does the granting of funds and the distribution of funds to industry for research and development affect the development of institutions of excellence in a certain area other than the activity of the Foundation?

Dr. WALKER. It would be quite indirect if the giving of funds to industry helps a university in the neighborhood of that industry. The industry might ask some of the university people to conduct some of the research under a DOD program or something like that, and there would be some effect in this direction, but I don't think a great deal, sir.

Mr. ROUSH. Does the growing imbalance in the distribution of Federal research funds to industry in any way endanger present and existing centers of excellence insofar as our institutions are concerned?

Dr. WALKER. No. I don't think it does because I think that the excellent universities are so strong that things like this really cannot affect them.

Mr. ROUSH. I would take issue with you on this point. It seems to me that you stress the fact that people tend to migrate where we have centers of excellence. There is an endangering of institutions in the Midwest. We lose 90 percent of the graduates of Purdue University to places other than the Midwest. If this imbalance should continue to grow, we would endanger the excellence of the universities in my section of the country or any section of the country which is described in terms of research funds as a poor section of the country.

Dr. WALKER. Yes, now you have mentioned Purdue as your school.

Mr. ROUSH. It is not my school. Indiana University is my school, but Purdue is in my State.

Dr. WALKER. As you know, there is considerable concern about the doctoral degree holders from these schools leaving that section of the country, and I suppose it could work in the reverse way. People might say, "Well, no one stays there; therefore, why go there for a graduate degree?"

This could happen. I think I defended myself by saying "indirect reasons."

Mr. ROUSH. That is all, Mr. Chairman.

Mr. DADDARIO. Mr. Davis.

Mr. DAVIS. Dr. Walker, I was just trying to apply your statements to my own part of the coutry. I happen to be from Georgia. The fact that Harvard or MIT might be progressing I don't believe means, at least in the Southeast, that we are retrogressing.

Our schools are growing very rapidly, the student body and the number of doctorate degrees are increasing every year, and it just occurs to me that progress in the centers may not mean retrogression in the hinterlands.

Do you think that is possible?

Dr. WALKER. I think it is not only possible, it is very true, sir, that education is going ahead so fast these days that in the words of the Red Queen "You have to run as fast as you can to stay where you are." I think we all find ourselves in this position.

Mr. DAVIS. I want to thank you for a very enlightening and stimulating statement. I want to say that having a liberal arts background rather than a technical background, it has been a source of considerable curiosity to me to try to find the line that separates science from engineering. Your statement was a great help to me this morning on that particular question.

Mr. MILLER. Would the gentleman yield to me?

Mr. DAVIS. Certainly.

Mr. MILLER. Doctor, he stresses this point that he has a liberal arts background. He is a lawyer by profession and an astronomer by avocation.

Dr. WALKER. That would almost make him an engineer.

Mr. DAVIS. I am a rank amateur, but very interested in that subject.

Mr. DADDARIO. You may as well add, Mr. Miller, he is also a Member of Congress.

Mr. MILLER. And he has been a judge.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Doctor, I am interested in the composition of the board as to its balance between the various scientific and engineering fields. I have a list of the members here in front of me, but I am not sufficiently acquainted with their backgrounds to know.

Could you give us an indication of how you feel the board is constituted in terms of its balance as between the physical sciences, the health sciences, the social sciences, and engineering? Could you give us also your general feeling as to the adequacy of the board in fulfilling the role of communication or coupling between the scientific community and the Foundation?

Dr. WALKER. Well, I don't think the balance between the disciplines you have mentioned was at all designed, but my feeling is it is very good. The members of the board, whether they are in the social sciences or physical sciences or in engineering, do communicate with each other very well, and I would be hard pressed most of the time to say whether or not a physicist or engineer or a social scientist was talking in the board meetings.

I think each member speaks up as we get into the area of his particular competence, but my general feeling is the distribution is just about right.

Mr. BROWN. Well, I think that is a very good statement for a chairman of that Board. I have been harping on the subject of the resources devoted to the social sciences by the Foundation, and looking at the membership of the Board I see only one person that I can really identify as a person definitely in the social sciences.

I want to ask your comment on the general problem here as to, first, do you feel that the Foundation has a positive responsibility to support basic research in the social sciences? Do you feel that the efforts in that line are adequate if you feel there is a positive responsibility? And do you feel that the voice of the social scientists is adequately represented by the one member that I positively identify and others that you may know about on the Board at the present time?

Dr. WALKER. My own personal feeling, Mr. Brown, is that the Board has been very timid about this, that we had our roots in the physical sciences—physics, chemistry, astronomy and so on—and that we were very timid about getting into engineering, and also timid about getting into the social sciences because these are not as comfortable to us as physics.

I think this is one of the things that the Board now ought to speak out on, and I think we now have a guideline. If we are going to have a Foundation for the arts and a Foundation for the humanities, then obviously I think the National Science Foundation ought to say that the social sciences are really part of our field of influence. And this is one of the problems that the Board ought to turn its attention to.

Mr. Brown. I am aware that the Board is concerned with this problem. Obviously its actions have indicated this in establishing committees to study it and a division within the organization.

I think the concern of this committee and my own is really how far do we go; which is the proper policy role, and obviously there is no present answer to this. We are seeking such an answer.

You are familiar with the work of the Office of Naval Research, for example. It is my understanding that this Office supports at least some research in the social sciences.

Dr. Walker. That is correct.

Mr. Brown. Now they seem to have no embarrassment about this to my knowledge. Could you comment on that?

Dr. Walker. Yes. Many of the Navy's problems have been in the area of the social sciences—for instance, the problem of just getting a crew to live together in a submarine which stays underwater for 30 days. I think the Office of Naval Research properly recognized this as a problem for the Navy and thus recommended some research in the social sciences.

Mr. Brown. They have also had a number of projects in somewhat broader fields of personnel and human management, as I recall, which I think have general applicability in any large-scale organization. The question is whether the Navy is perhaps the best organization to do this.

Another example from recent newspaper reports of research being done in foreign countries by the DOD are Project Camelot and a similar project in Brazil. This is basic research in the social sciences. The policy framework, in which these have been authorized, is apparently not clear.

They apparently went into them mainly because DOD could get money, and a more appropriate agency could not. This is the reason I think this question does need exploration at the present time.

Leaving that subject for a moment, I want to go into this matter of your remarks with your other hat on, the Engineer's Council. You have touched on some things which, as Chairman Miller indicated, are extremely significant from the standpoint of the progress of our society. Is it not true in a very real sense that a large part of the problems which face this country today in terms of a better adaptation to its environment are engineering problems?

Dr. Walker. I think so.

Mr. Brown. Are you suggesting that the National Science Foundation is the place in which effort should be made to solve these problems? For example, the ones that you gave, a national communications system improvement program in the Post Office, a national transportation improvement program, a national water reclamation program, major engineering projects all requiring the relating of science to the needs of our people.

Does it seem to you that the National Science Foundation should be taking the lead in these areas?

Dr. Walker. This is a policy decision, I think, in which the Congress as well as the Board of the Foundation and the administration have to share. My feeling would be that the National Science Foundation could do this and probably should do it, but wiser men might say there is another avenue to do it.

Mr. BROWN. The real problem, it seems to me—and I ask for your comment on this—is that the Congress itself has not decided that these are problems to which it should address itself. Would you feel that this is a correct statement?

Dr. WALKER. Yes. My observation would be that Congress has not decided that they are problems, and in the cases where they have, there has really been no clear-cut decision as to whether the work should be done.

Mr. DADDARIO. Would you yield there for a moment, Mr. Brown?

Mr. BROWN. Certainly.

Mr. DADDARIO. You have touched on one point which inhibits a better performance in areas where there is no profit out of a device or a system. You are actually recommending that through the National Science Foundation the research could be done which would demonstrate the feasibility to perform certain of these programs. Then I would imagine that you would decide whether to do it through the private sector or through the Federal Government or through a combination of the two such as the Communications Satellite Corp.

Dr. WALKER. That is precisely it.

Mr. MILLER. Will the gentleman yield?

Mr. BROWN. Yes.

Mr. MILLER. Doesn't it come down to this, one of the points you wish to make, and I will cite two instances in my own State, frankly affecting my own district, where the cities and counties around San Francisco Bay have bound together and set up a political entity for a rapid transit system. They voted $800 million worth of bonds to start with.

Then the Federal Government made a grant to develop a rapid transit system, and now they are in the process of trying out new types of equipment. However, the grant from the Federal Government doesn't come from the National Science Foundation, though they are dealing in an engineering problem, it comes from Housing and Home Finance.

Dr. WALKER. That is right.

Mr. MILLER. Correspondingly, in the port of Oakland a man, who operates the helicopters in the San Francisco Bay area, who is a good entrepreneur, and who is willing to take a chance, decided to try hovercraft in this area. This area is the first place where hovercraft will be put into public operation in the United States. It will start next month. But again when he wanted to get Federal aid, it is from the Housing and Home Finance Agency, which has no capability in the field of engineering.

As a matter of fact, when we wanted to bring these craft out, there was a question as to which agency do they fall under, and who is going to regulate them.

So the ICC, the CAB, and the Maritime Administration had a meeting. One said: Are they trucks? Another said: Are they airplanes? And another one said: Are they ships? Someone said they were ships. Then the Jones Act was in our hair. We had to go to DOD to sign a declaration saying they were interested in the operation because we had to buy these ships from an English firm. They will be manufactured in this country under a patent, but to get them now we had to buy them in England.

The point I want to make is that the Federal money going into this thing is coming from the Housing and Home Finance Agency. I have no fight with that. My complaint is, What have we done in the field of hovercraft or in the field of rail transportation to modernize and bring it up to date?

Certainly the railroads aren't going to spend money to do it. They should, but they are not. Are we going to sit back and be strangled by poor transportation because we don't spend money to examine and probe it? Now we are going to do a lot of things between here and Boston. I think the last program is to dig a great subway between Washington and Boston. Maybe that will come in a few hundred years. What are we going to do about the near future? How are you going to get down from Hartford to New York?

Dr. WALKER. You have got me, Mr. Chairman. I have a problem in that regard.

Mr. DAVIS. Will the gentleman yield to me?

Mr. BROWN. Yes.

Mr. DAVIS. Dr. Walker, I want to make the observation that some very powerful human factors enter into this question. As Dr. Holloman of the Commerce Department pointed out when he testified before our committee, every department tends to fund its own science. For instance, the Post Office Department has studies involving computers. The Department of Agriculture has its own. This is true all the way across the board.

It is a fact that it is just literally impossible to hem up science, and each person who has a job to do naturally wonders if there isn't some help to be had at the hands of science, and so he takes part of his money and spends it on science.

I think if you did try to say that all the science of communications or of transportation should be relegated to this, that, or the other agency, you would find that you just simply can't trap science that way. You couldn't keep, for example, the Department of Commerce from using some of its money for the science or the engineering of transportation. I think the human factors in there are something really to be reckoned with.

Dr. WALKER. We find this in universities, sir. You have a department of electrical engineering, and pretty soon they are doing physics and mechanical engineering, and you can't stop it.

Mr. BROWN. We have some very fundamental philosophical problems involved in this discussion, the one that Mr. Davis raises about containing science in any one organization, or engineering. The other problem raised with regard to the support of activities which may be construed as being in the private enterprise sector, and the considerable fear that exists that Government funding in these areas means Government control and a step in the direction of a socialistic type of government. We really need to have a great deal more confidence in our dedication to the free enterprise-private property system, and with the recognition we may be enhancing that system through the proper expenditure of funds to solve some of these problems.

For example, in the space program as a whole we have recognized that private enterprise is not the proper vehicle to explore the Moon or Mars, and yet private enterprise has benefited tremendously from

the Government efforts in this area. I hope it will continue to benefit, just as I think it would benefit if we were to undertake a national program concerned with the development of a good transportation system or a good water conservation system.

I think this would be a shot in the arm for our whole economy. But as long as there is a fear that the Government movement in this direction is a step toward socialism, and this is worse than the Devil itself, we are not likely to make much progress in this area.

I have no further questions, Mr. Chairman.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. No questions.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I regret to say that other activities, which I didn't expect would occur, kept me from being here earlier. I was most interested in your statement. However, I think since both you, representing the Board, and Dr. Haworth are here, I should say one thing has been very clear to me from the last several weeks of these hearings. There have been extremely few serious criticisms of the National Science Foundation per se, or of the Board or its operations, and that in general what has come out has been to the Foundation's favor rather than to its detriment. I think it is well to take note of this in passing.

We have learned a great deal more about the other agencies that the Foundation deals with rather than about the operations of the National Science Foundation itself, and interaction between these, where I think a great deal of difficulty may lie.

I have asked a number of persons this question: What is the relationship of the Board to the Director, and what is its responsibility and authority? You said on page 2:

The Board may delegate authority but not responsibility * * * in deciding which way the Foundation must go.

As far as I can determine, the Director reports to both the Board and the President, and I haven't quite understood who does what, and what role, for example, the President's science adviser has in terms of the policies established by the Board.

For example, let us suppose the matter of transportation should come up, and let's say the Board felt that the expansion of effort on hovercraft may be desirable. At this point suppose the Board were to vote 3 to 2 that there should be an additional $10 million spent in the area of hovercraft. Now, what inhibitions would you have in making such a decision as a Board?

Dr. WALKER. Thankfully, this situation has never arisen since I have been on the Board where we have had an unresolved disagreement. But the Board does approve the request for an appropriation, and I suppose if we did meet an impasse like this, the Board could insist that a line item be made in the request to the Bureau of the Budget and the Congress that something be done about hovercraft.

Mr. VIVIAN. I am not referring so much now to a dispute between the Director and the Board. I am speaking of a dispute between yourselves and the Budget Bureau and the President's Office. Let us say you wanted more money spent on these methods of transportation which seem to be halfway between sea, land, and air, but never on one of them, and let us say there is objection, for example, from the

other departments that are involved because they want to be leading lights in this expansion. You make a decision—and I will even give you a unanimous decision on the part of the Board—that you should do something.

What happens now if you should run into some objections from the other agencies? Just how does this get resolved? As the act reads, it says the Board has the authority and responsibility for the National Science Foundation. Therefore, you can recommend to Congress anything that you see fit.

Dr. WALKER. I suspect this would be resolved at the President's Office level, before it ever got into the Congress.

Mr. VIVIAN. In other words, the Foundation's Board does not really desire to have the authority to exercise its prerogatives according to law?

Dr. WALKER. Speaking for myself, I don't see how we could.

Mr. VIVIAN. How are the Budget Bureau requests processed? When you come up with a suggested budget for the following year, this request, I presume, is reviewed by the Board and passed on by the Director to the Bureau of the Budget. Has the Bureau of the Budget turned down significant items or requests?

Dr. WALKER. I couldn't answer this question. You would have to ask the Director that.

Mr. VIVIAN. Have they been?

Dr. HAWORTH. Yes, they have.

Mr. VIVIAN. Have these amounts been significant fractions of the year's budget?

Dr. HAWORTH. I don't think you can single out any one item and say it has been a significant fraction. There have been items. Of course, the amounts for the various items are subject to the Bureau's approval and negotiations between the Bureau and the Director and so on. But there has been initiation of new programs that have been turned down or postponed.

Mr. VIVIAN. Can you give me some idea whether those programs that have been turned down have been those which the Board and yourself felt should be started, for instance, in new areas and which were cut off for budgetary reasons or which were cut off for what I will call conflict-of-agency reasons?

Dr. HAWORTH. I don't think of any, Mr. Vivian, that have been other than for financial reasons.

Mr. VIVIAN. Strictly financial?

Dr. HAWORTH. Yes. Remember my experience is very limited. I have been here only 2 years.

Mr. VIVIAN. Perhaps I should ask Mr. Walker, in his experience, which is slightly longer in this regard.

Dr. WALKER. I don't recall any that have been turned down for conflict of agency. We often get turned down on amounts that we want for specific programs.

Mr. VIVIAN. For example, following up on Chairman Miller's comments, suppose you concluded that the transportation system needed an influx of new ideas and you put in a request to the Bureau of the Budget. Do you anticipate that it wouldn't be turned down because of funds?

Dr. WALKER. I think as to the one you have chosen, you would get into quite a hassle whether we or Commerce did it.

Mr. VIVIAN. This question has come up many times.

I feel the Board's position is not a very thoroughly defined one even though it has been very successful in its functions. I think the words in the statutes don't have much relationship to the facts of life.

Dr. WALKER. I don't think the Board has ever exercised its authority nor its responsibility to really search out areas which need to be investigated and then point them out as areas that are neglected. This isn't an easy thing to do, and the work of the Board, as you know, has been growing very fast, and new jobs are presented to it so often, that it is kept busy with this sort of thing. Instead of innovating, it has been filling needs.

Mr. VIVIAN. I have felt for some time that the Board's role with reference to the overall scientific interest of the Nation is basically prescribed by two things. The first is that it really in a sense cannot dispute with the President on major expenditures, and I agree that it would be nonsensical. Second, the Board represents principally the universities and institutes of the Nation rather than principally the overall scientific community of the Nation.

Recommendations had to be viewed from what I will call the recommendations of the university community in a broad sense.

Dr. WALKER. That is correct.

Mr. VIVIAN. Therefore, when you run across places where private industry is very heavily involved, such as transportation, you immediately come into a conflict of who is carrying the ball. Yet I wonder if that is desirable because I think many of us feel that some of the most desirable directions of activity, are being slowed down by lack of assurance that if you progress in this direction, you wouldn't be chopped to bits.

I am trying to find examples of where you have tried to progress and have not been chopped to bits perhaps, but have had a few gouges taken out. Where have been the battles you lost?

Dr. WALKER. These are difficult for me to give you because we haven't grabbed the ball and run with it sometimes when I think we should have done it.

Mr. VIVIAN. There is an old saying which goes to Members of Congress, if you win by more than 55 percent, say 60 percent of the constituents, you have made a mistake because you haven't disagreed with people often enough.

I wonder if the same thing doesn't apply to the Board, and perhaps the National Science Foundation in total, perhaps you should have lost a few fights.

Dr. WALKER. I wouldn't disagree with you, sir.

Mr. VIVIAN. I will stop there.

Mr. MILLER. You are ahead now.

Mr. DADDARIO. Dr. Walker, I hope we might be able to send a series of questions to you. Obviously there are many more questions that we could ask than we are permitted by time.[1]

We appreciate your coming and grateful for your assistance. Thank you.

Dr. WALKER. Thank you, sir.

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

Mr. DADDARIO. Our next witness is Mr. William T. Knox, who is with the Office of Science and Technology in the Executive Office of the President.

I have had occasion to know Mr. Knox over a period of time. He was with the Esso Research & Engineering Co., from which he is now on a sort of a sabbatical leave working with the Government, and I think his biographical sketch in regard to that should be of interest.

His job is to assume responsibility for stimulating development of more effective scientific and technical information systems, which includes a great deal of research management. This is a subject which the committee has heard a great deal about, Mr. Knox, and we are pleased you are with us this morning.

Mr. DAVIS. Mr. Chairman, if I may interpose this comment, I also noted from his biographical sketch that he is a fellow son of the State of Georgia. I want to particularly welcome him here before this committee.

I think you are only the second witness that I have had occasion to listen to who is from my own State. We are all happy to have you.

STATEMENT OF WILLIAM T. KNOX, CHAIRMAN, COMMITTEE ON SCIENTIFIC AND TECHNICAL INFORMATION OF THE FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY; ACCOMPANIED BY COL. ANDREW A. AINES, EXECUTIVE SECRETARY, COMMITTEE ON SCIENTIFIC AND TECHNICAL INFORMATION, FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Mr. KNOX. Mr. Chairman, could I ask Colonel Aines, who is executive secretary of COSATI, to join me?

Mr. DADDARIO. Certainly.

Mr. KNOX. I want to say to the members of the subcommittee I am glad to appear here today as it makes a comprehensive review of the National Science Foundation. As the chairman has said, the area that I am to deal with is that very large and ill-defined complex of activities known as scientific and technical information activities. To put it a little more accurately, it is the systems by which information is transfered in order to promote the progress of science and technology. Another way of characterizing this is to talk about the systems that support science and technology.

I mention these because they call attention to the main concern, which is the progress of science and technology. Too often there has appeared to be an emphasis on scientific and technical information systems and problems within themselves—without relating them to the cause and the reason for their existence, which is the progress of science and technology.

President Kennedy focused on the real issue when he said in 1963:

> One of the major opportunities for enhancing the effectiveness of our national scientific and technical effort, and the efficiency of Government management of research and development lies in the improvement of our ability to communicate information about current research efforts and the results of past efforts. Strong science and technology is a national necessity and adequate communication is a prerequisite for strong science and technology.

May I also mention another overemphasis in recent years. Too often there have been repetitions of fascinating falsehoods about the inadequacies of the present system. One such myth was traced recently by Dr. Oettinger of Harvard. The myth, which you may have heard yourselves, was the fact that 5 years and $250,000 were allegedly spent in the United States to needlessly duplicate a result published in the Soviet Union in 1950 and that solutions to important military problems were delayed by those 5 years. Dr. Oettinger painstakingly discovered that—

the trivial results in question were surprisingly well known to all specialists most concerned, in at least one instance as early as 1937.

Dr. Oettinger further states that—

It is therefore entirely out of the question that anyone would knowingly have spent $200,000 on this matter or that any important project would have been hurt by a delay in the discovery of the article.

I recognize that a modern, healthy, information system is as vital to the health of the overall scientific and technological programs of this country as a healthy circulation system is vital to a healthy human being. I could even say, just as a healthy transportation system is vital to our economy, too.

However, although there are many specific aspects of our present information system which we know could be considerably improved, I feel that steps for improvement must be based on well-reasoned, analytic studies of the total needs, consideration of several alternate possible solutions, much thought about costs and controls and future trends, and a number of large-scale experiments.

This brings me to some of the things that Dr. Walker was talking about, about our need for an organized engineering systems approach. This is certainly another area in which this would be profitable. In this field we have the same type of organizing and financing problems, too, within the Federal Establishment, which the committee just discussed with respect to how to get things accomplished in transportation systems or our water systems.

My role is that of chairman of one of the committees of the Federal Council for Science and Technology; namely, the Committee on Scientific and Technical Information. With your indulgence, I will refer to this committee henceforth as COSATI, a nickname or acronym now known throughout the Nation in information circles.

I would like also to pay tribute at this point to the individual members of COSATI, who are very able, dedicated people, and who feel a keen compulsion to work together for the common interest.

Let me stop saying this big mouthful of "scientific and technical information," and henceforth, when I refer to "information," you will know I refer to scientific and technical information.

In addition to my chairing COSATI, I serve Dr. Donald Hornig, Director of the Office of Science and Technology, as technical assistant for information activities.

The relationship of the National Science Foundation to information activities was covered in detail in the report entitled, "The National Science Foundation—A General Review of Its First 15 Years," prepared by the Science Policy Research Division of the Legislative

Reference Service. In addition, both Dr. Haworth and Dr. Hornig have referred to the Foundation's activities in this area in their testimony given earlier. I do not plan, therefore, to discuss, except in very general terms, the Foundation's relation to the Federal Government's overall program in information.

Rather, as your letter of invitation suggested, I shall present for your information, as you review the Foundation's activities and plans, some of the highlights of the total governmental programs in information as seen from COSATI and the Office of Science and Technology.

Let me first outline the scope of COSATI's concerns. As you can imagine, they are very broad, since they are related to all the scientific and engineering disciplines and to all of technology. As you can also imagine, since COSATI has existed for only 3 years, there are many problems still waiting solutions. Under the recent chairmanship of Lt. Gen. William J. Ely, U.S. Army, and continuing under my leadership, the substructure of COSATI is being reorganized into eight panels. The panels already in being are as follows:

OPERATIONAL TECHNIQUES AND SYSTEMS

This panel is concerned with: acquisition, accession, in libraries, abstracting, indexing, announcement, distribution, terminology control, equipment compatibility and convertibility, wholesale and retail resources, specialized information centers, libraries, and depositories. This is a big order. This is our "workhorse" panel, charged with improving the quality of performance and coordination of current and near future Federal agency programs.

INFORMATION SCIENCES TECHNOLOGY

The missions assigned to this panel are to make recommendations for the orderly development of information sciences technology by avoiding unnecessary duplication of agency R. & D. efforts and by identifying gaps in agency R. & D. programs; and the orderly transition from current to improved systems.

EDUCATION AND TRAINING

This panel helps us look for improved education and training of information specialists, and means for increasing their supply, which is a very short supply. It will also help educate scientists and engineers and managers in the use of information resources and system.

We are considering other panels at present.

INTERNATIONAL ACTIVITIES

This country needs information produced by scientists and engineers in other countries. In these days of plans for computerized information systems serving an international community, it is important to have a panel to help coordinate Federal agency activities; to set standards for systems, to recommend international exchange policy and procedure, and to improve the many translation programs carried on in and out of Government.

INFORMATION GENERATION

This will include such areas as reporting techniques, input quality control, technical writing, meetings and symposia, and the large area of security, proprietary, and copyright matters. In a word, it is concerned with the beginning of the information cycle.

INFORMATION USERS

As the name implies, this panel will be concerned with users and their needs for information and data; also, with steps to be taken to let users know the information resources that exist, and how to get to them.

EXTERNAL RELATIONSHIPS

The Government is a big factor, but not the only factor in the information business. Industry, the universities, trade associations, and technical and professional societies have a considerable stake in science and technology, and the information systems serving it. This panel will be charged with the responsibility of safeguarding their interests.

BUDGET AND STATISTICS

The panel will help with budget reviews and analyses of agency information programs, by developing commonly agreed upon and useful statistics.

COSATI's concerns thus embrace not only systems actually used to transfer documents and information from one user to another, but also embrace the initial publication processes and the producer of information, the user groups with their varying information needs, and the education and training of information systems operators and the producer-user groups in the use of modern information systems. Not only is there a large service function here, but information systems also have their own large research and development program.

The size of the Federal Government's information program is not easy to determine. This is basically because it is difficult to make a distinction between some information activities and the research or engineering activities of which they are an integral and essential part. To all scientists and engineers, information transfer is an inseparable part of their science and engineering. One study of the work habits of chemists has shown that research chemists spend as much as one-half their time in communicating.

. Mr. DADDARIO. Mr. Knox, will you provide, for the record, the membership of COSATI, and the panels?

Mr. KNOX. I will be glad to do so, sir.

(The information requested is as follows:)

FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY, COMMITTEE ON SCIENTIFIC AND TECHNICAL INFORMATION

Chairman: William T. Knox, Office of Science and Technology, Executive Office of the President.

Executive Secretary: Col. Andrew A. Aines, U.S. Army, Office of Science and Technology, Executive Office of the President. (22421)

MEMBERS

Dr. Burton W. Adkinson, Head, Office of Science Information Services, National Science Foundation. (Alternate): Henry J. Dubester, Deputy Head, Science Information Coordination Section, OSIS, National Science Foundation.

W. Buril Barclay (RD-67), Chief, Domestic Coordination Staff Systems R. & D. Service, Federal Aviation Agency. (Alternate): ——— ———, Chief, Library Services Division, Federal Aviation Agency.

Edward J. Brunenkant, Director, Division of Technical Information, Atomic Energy Commission. (Alternate): John Sherrod, Assistant Director for System Development, Division of Technical Information, Atomic Energy Commission.

Walter M. Carlson, Director of Technical Information, Office of Director of Defense Research and Engineering. (Alternate): Dr. Robert B. Stegmaier, Jr., Administrator, Defense Documentation Center.

Melvin Day, Director, Office of Scientific and Technical Information, National Aeronautics and Space Administration. (Alternate): Paul Feinstein, assistant to Director, Office of Scientific and Technical Information, National Aeronautics and Space Administration.

H. H. Eckles, assistant to the science adviser, Department of the Interior. (Alternate): Leslie Scattergood, Chief, Branch of Reports, Department of the Interior.

Foster E. Mohrhardt, Director, National Agricultural Library, Department of Agriculture. (Alternate): Dr. Harold C. Knoblauch, Associate Administrator, Cooperative State Research Service, Department of Agriculture.

William H. Mills, Office of International Scientific Affairs, Department of State. (Alternate): Curtis L. Fritz, Chairman, Foreign Affairs Information Management Effort (FAIME), Department of State.

Dr. Donald A. Schon, Director, Institute for Applied Technology, National Bureau of Standards. (Alternate): Bernard Fry, Director, Clearinghouse for Federal Scientific and Technical Information.

Dr. William H. Stewart, assistant to the special assistant to the Secretary (health and medical affairs), Department of Health, Education, and Welfare. (Alternate): Dr. F. Ellis Kelsey, special assistant to the Surgeon General (science information), U.S. Public Health Service.

Dr. Benjamin B. Wells, Assistant Chief, Medical Director for Research and Education in Medicine, Department of Medicine and Surgery, Veterans' Administration. (Alternate): Frank R. Smardak, Coordinator, Scientific Information, Department of Medicine and Surgery, Veterans' Administration.

J. Lee Westrate, Office of Management and Organization, Bureau of the Budget, Executive Office Building.

OBSERVERS

John K. Vance, Central Intelligence Agency.

Dr. David Z. Robinson, Office of Science and Technology, Executive Office of the President.

Edward E. Harriman, Office of Research and Engineering, Post Office Department.

G. W. Seymour, Chief, Research and Development, Small Business Administration.

Herbert Turner, Agency for International Development (TCR). (Alternate): Erwin Lachman, Chief, Science Information Unit, Office of Research and Analysis, Agency for International Development.

LIAISON

Dr. Dwight E. Gray, Chief, Science and Technology Division, Library of Congress.

Dr. Theodore W. Taylor, Assistant to the Secretary, the Smithsonian Institution. (Alternate): Dr. Monroe Freeman.

PANEL ON EDUCATION AND TRAINING

John Sherrod, Assistant Director for Systems Development, Division of Technical Information, Atomic Energy Commission (Chairman).

Charles M. Gottschalk, Office of Assistant Director for Systems Development, Division of Technical Information, Atomic Energy Commission (Secretary).

Joseph Becker, Central Intelligence Agency.

Dr. Frank L. Schick, Assistant Director, Library Services Branch, Office of Education, Department of Health, Education, and Welfare.
Miss M. Joan Callanan, professional assistant, advanced science education, Division of Graduate Education in Science, National Science Foundation.
Edward K. Grimes, Special Projects Office (AFRSTS), Directorate of Science and Technology, Headquarters, U.S. Air Force.
Kirby B. Payne, Assistant Director, Field and Special Services, National Agricultural Library.

PANEL ON INFORMATION SCIENCES TECHNOLOGY

Dr. Ruth Davis, Office, Director of Defense Research and Engineering (Chairman).
Dr. Harold Wooster, Office, Director of Defense Research and Engineering.
Charles J. Austin, National Library of Medicine.
Mr. Curtis L. Fritz, Chief, Foreign Affairs Information Management Effort, Department of State.
Dr. Joel O'Connor, data processing officer, Division of Technical Information Extension, Atomic Energy Commission, Oak Ridge Operations Office.
Van A. Wente, Chief, Documentation Branch, Scientific and Technical Information Division, National Aeronautics and Space Administration.
Richard See, program director, information systems program, Office of Science Information Service, National Science Foundation.
Miss Mary Stevens, National Bureau of Standards.
Dr. Bruce Waxman, Research Grants Review Branch, Division of Research Facilities and Resources, National Institutes of Health.
Dr. Richard Wilcox, Office of Naval Research, Department of the Navy.

PANEL ON OPERATIONAL TECHNIQUES AND SYSTEMS

Dr. Armen G. Abdian, Defense Documentation Center, Defense Supply Agency (Chairman).
Budd C. Moyer, Defense Documentation Center, Defense Supply Agency (Secretary).
Gerald W. Beveridge, Chief, Technical information Division.
John Forbes, Chief, Division of Indexing and Documentation, National Agricultural Library.
Paul C. Janaske, Clearinghouse for Federal Scientific and Technical Information.
Eugene P. Kennedy, Library Services Division (HQ600), Federal Aviation Agency.
Hubert Sauter, Chief, Technical Services Branch, Scientific & Technical Information Division, National Aeronautics & Space Administration.
Robert L. Shannon, Assistant Director, Division of Technical Information Extension, Oak Ridge Operations Office, Atomic Energy Commission.
Seymour I. Taine, program director, Federal science information program, Science Information Coordination Section, Office of Science Information Service, National Science Foundation.

Mr. KNOX. Recognizing the difficulties in separating information services from other aspects of research and development, COSATI has developed some very rough budget estimates for information programs of executive branch agencies for fiscal year 1966, as follows:

Colonel Aines shows these rough estimates on this chart (fig. 1).

Science-technology information activities

	Millions [1]
Publication and distribution	$130
Bibliographic and reference service	80
R. & D. information sciences and systems	60
Symposia and technical meetings	40
Information centers	20
Management and training	20
Audio and visual media	10
Budget issues	10
Translations	5
Support publications	5
Total, estimated	380

[1] Numbers rounded. Estimated obligations, not expenditures.

FIGURE 1

First of all, I want to note we have rounded the numbers, and they are estimated obligations, not expenditures.

The largest single item is for publication and distribution—this refers to the vast amount of published material that is turned out by individual Federal agencies—reporting results of scientific and technical programs. It also covers the cost of distributing this material.

Bibliographic and reference services refer to such things as abstracts and other bulletins. The Atomic Energy Commission turns out Nuclear Science Abstracts, for example. This category also refers to agency library services, and things like that.

You will notice about $60 million a year is going into research and development in the technology that is applicable to information transfer. A lot of this is in the military.

Symposia and technical meetings——

Mr. DADDARIO. There will be three bells.

Mr. KNOX. We feel like ringing a bell on the symposia and technical meetings, too, sir, because they account for about $40 million of these estimated obligations.

Information centers, that is, special centers operating on one subject aspect of science and technology, are shown at about $20 million. The remainder of the categories become progressively smaller, about $5 million on translations and $1 million on actual subsidy of scientific and engineering journals published by nonprofit, non-Government organizations.

Mr. DADDARIO. Also, if it is possible to break down for the record the agencies involved in the expenditures of these funds——

Mr. KNOX. It would be extremely difficult, Mr. Chairman. The estimates here are not consistent, agency to agency. Estimates account for a substantial part of the total dollars which we are showing here, and because of the interrelation of the actual research effort itself with these dollars we talk about here, I think it would be practically—well, it could be misleading, and I am not sure it would be very meaningful.

Mr. DADDARIO. Why don't we leave that go at the moment and see if it is necessary.

Mr. KNOX. All right.

Mr. DAVIS. May I ask a question, Mr. Chairman?

Mr. DADDARIO. Yes.

Mr. DAVIS. You say this is the information programs of executive branch agencies. I take it that includes departments?

Mr. KNOX. Yes, sir.

Mr. DAVIS. The whole executive branch?

Mr. KNOX. The whole executive branch.

Mr. DAVIS. What sort of definition did you use for what would amount to an item of scientific and technical information?

Mr. KNOX. These categories are the ones that we tried to solicit estimates from the agencies on, for example, how much money they were actually spending to print documents.

There is a very large, for example, printing establishment down at Oak Ridge, run by the Atomic Energy's Division of Technical Information.

Mr. DAVIS. Suppose someone ordered an almanac? Would you consider that as a piece of information that would be added to that total?

Mr. KNOX. The categories were restricted to information that was rather easily construed as being in the fields of science and technology, in support of the research programs either within the Federal Government, or supported by the Federal Government, outside.

Mr. DAVIS. I see. It had to be in support of some research program?

Mr. KNOX. Or the results of some research program. That is right.

Mr. BROWN. Mr. Chairman?

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. Could we clarify that just a little bit more by indicating some examples of what this does not include? For example, this does not include public relations activities of the various agencies, I presume?

Mr. KNOX. This is correct. It would not include, for example, the actual experimental procedures, themselves, the actual laboratory work or the actual hardware costs, or the actual procurement of the items.

Mr. BROWN. But in the information field, there is a great deal of publication that does not deal with science and technology?

Mr. KNOX. This is correct. This has nothing to do with the agencies' public information program, as an example.

Mr. BROWN. Thank you.

Mr. KNOX. The part that is played by the National Science Foundation in these information programs is highlighted by this following chart (fig. 2.)

Sci-Tech information activities (comparison of NSF and total Federal agency programs, fiscal 1966)

[In millions of dollars] [1]

Function	NSF	Total
Translations	2.4	5
Information centers (SIE, NRC)	3.6	20
R. & D. in information sciences and systems	5.1	60
Other functions	7.3	295
Total, estimated	18.4	380

[1] Numbers rounded. Estimated obligations, not expenditures.

FIGURE 2

It is a summary presentation to call attention to the primary activities of NSF in this field. You will notice in the translation category the Foundation has obligated about half the total obligated by the executive branch, \$2.4 out of \$5 million. This is in support of translations of foreign language scientific and technical materials. It also operates the Science Information Exchange, or has the management responsibility for the Science Information Exchange, and the National Referral Center for Science and Technology, which are two components of the national network. For those two activities it has budgeted \$3.6 million out of a total of \$20 million. It spends about 8 percent of the total spent by the executive branch for research and development in information sciences and systems. This is less than the 12 percent, on the average, of basic research support, that the Foundation gives relative to the total Federal support for basic research.

Dr. HAWORTH. I think, if I may interrupt, I think the 12 percent refers to our support of academic research. As to total research, it is far less than that.

Mr. KNOX. Overall, NSF supplies about 4.5 percent of the total Federal agency funds for information activities. This low value is due in large measure to NSF not having large in-house information systems, as do many of the other Federal agencies.

Let me turn now to some of the more general problems facing the Federal Government and look at them through the eyes of COSATI.

Since COSATI is a committee of the Federal Council for Science and Technology, its main functions have paralleled those of the Council. In its field of information, COSATI has served as a means for:

1. Identifying problems of concern to more than one agency;
2. Developing an interagency consensus for steps to ameliorate or eliminate the problems; and
3. Exchanging information among Federal agencies.

In the last 3 years, as a result of COSATI's studies and recommendations, a number of actions have been taken by Federal agencies to improve information systems. Some of these are:

1. A uniform policy to guide Federal agencies on financial help to nonprofit, nongovernmental scientific publications. This is the so-called page charge policy, whereby Federal agencies pay, if requested by the publisher, certain costs of publication.
2. A standard for microforms of technical reports. We call these "microfiche,"—if you haven't seen what a "microfiche" is, I thought you would like to see one. Colonel Aines has a sample. We look for this new standard to create a new, large market, and thus lower unit costs.
3. A uniform method for identifying Federal reports. This is called descriptive cataloging, and the technique is of particular help to those people who have to store and retrieve reports.
4. Finally, a subject category list to be used throughout the Federal Government for the announcement of reports.

This will make it easier for Federal report users to locate information. I have copies of these standards here if you would like to take a look at them later, or now.

These COSATI actions do not have the glamor of a spacewalk, but they are very significant actions in bringing about better coordination of Federal and non-Federal information activities. We will have to follow their implementation, and modify and correct them when necessary. We are also working hard on other standards and policies.

In addition to this kind of action whereby individual agencies and non-Government organizations have been enabled to make their own information systems more effective and/or more efficient as components of the total national network, COSATI has been the mechanism by which, or with whose endorsement several new organizations have been created to carry out special functions of the national network. These new central organizations are:

1. The Clearinghouse for Federal Scientific and Technical Information, operated by the Department of Commerce, which is primarily a technical reports dissemination agency.
2. The Science Information Exchange, which this committee, I believe, is familiar with, operated by the National Science Foundation

and the Smithsonian Institution, which is perhaps better called the Federal Research Project Registry.

3. The National Referral Center for Science and Technology, operated by the National Science Foundation through the Library of Congress, which is an inventory of who knows what in science and technology in the country, and is also a device for referring people to those resources.

4. The National Standard Reference Data System, operated by the Department of Commerce and designed to provide this country with critically evaluated compilations of numerical data, very essential for engineering work.

Now, in another kind of activity, as Dr. Hornig mentioned in his testimony before this committee, about 6 months ago, following several suggestions from committees of the Congress that the executive branch exercise stronger, more aggressive leadership in this area, an interdepartmental COSATI task group began a top-level planning effort. This effort is focused on developing the conceptual framework for a plan for improvement of the overall complex of scientific and technical information activities in the United States. Congressional committees playing a leading role in this area have been the House Committee on Science and Astronautics, the House Select Committee on Government Research, an Ad Hoc Subcommittee of the House Committee on Education and Labor, and the Subcommittee on Government Reorganization of the Senate Committee on Government Operations.

In order to develop the conceptual framework in a realistic fashion, it was necessary to consider also the activities outside the Federal Establishment, since the non-Federal and Federal activities are mutually dependent on one another, and large sums of Federal funds go directly or indirectly in support of these activities. Very early in the deliberations of the COSATI task group the importance of continuing dialogs with representatives of the various components of the complex of information systems was recognized. Within the Federal Government there is a readymade mechanism; namely, COSATI, present. But for non-Federal scientific and technical information activities there is no such mechanism. We have, accordingly, participated in a number of special meetings held to present the task group's preliminary thinking regarding a concept toward which the information systems in the United States could develop. These meetings have already been held with top level representatives of scientific and engineering professional societies, industrial and trade associations, the technical and business press, and library groups.

Although there are many other areas of interest, the task group has focused its efforts so far on formalized communication mechanisms, primarily document-handling mechanisms. The group is being assisted by a study team from the System Development Corp. As a first result of this cooperative effort, I hopefully anticipate a report to be issued this fall. The functions and relations of major components of the document-handling system, such as abstracting, indexing, and alerting services, are being studied. Another major area of interest is the impact of advanced technologies on the information transfer network.

What have we developed so far? First, we have concluded that the farflung, widespread nature of the information system can be roughly conceived as in part analogous to the telephone network, which is a mechanism for connecting people who want to know or to talk, with other people who either have the desired information or who are willing to listen. It is a mechanism completely at the service of its users, and it demands only an elementary knowledge to be able to use it. The telephone system operates on a real-time basis, however, and this is a big difference from information systems, which in part transfer knowledge acquired some years ago to today's users.

In order partly to recognize this difference in user need, and partially because of the different functions and different types of staff involved, we have, in our preliminary thinking, divided the body of the national network of information systems into two parts. These parts will be a complex of library systems (document-oriented, such as traditional libraries), and a complex of information evaluation and retrieval systems (information-oriented).

There seem to be necessary several libraries at the national level, handling documents in such fields as medicine, agriculture, engineering, earth sciences, physical sciences, behavioral sciences, et cetera.

I am not saying they have to be separate entities, but these subject areas appear to be desirable.

Each of these libraries would be concerned with acquiring all the pertinent literature in its field, cataloging or indexing it, announcing the availability of the literature, and providing copies, if requested. These would be structured, operated, and administered in somewhat similar manners. Perhaps each library would be responsible to a Federal agency with primary mission responsibilities in it field of interest, such as the National Library of Medicine which reponds to the mission of the Department of Health, Education, and Welfare. Coordination and compatibility among the libraries would be a primary goal really from the beginning, and a question for early decision would be the mechanism for bringing about this coordination.

Because of the size of our population, and the diversity of demands made on libraries for documents, ranging from help to the teenage student to the needs of the lay adult to the needs of small and large business and the professions, the rest of the library network will be essentially retailers of documents. Other library systems (Federal, college, and university, public, specialized, industry, institutes, schools, et cetera), would, as now, look to the national libraries for loan of documents, catalogs, et cetera, as may be appropriate, and would, in turn, provide some of the input to those libraries. But their main role would be to serve those users who will be satisfied with documents.

The other part of the system—the complex of evaluation and retrieval systems—would consist of those activities of Government agencies, universities, industries, and societies (professional, scientific, and trade) that are concerned with providing information, as opposed to documents, to specific audiences directly concerned with science and technology, namely, the scientists and engineers themselves, and managers of scientists and engineers. The elements of this system would be expected to:

1. Provides secondary current awareness, such as abstracts bulletins;

2. Analyze and evaluate information; not only the information contained in documents, but that information just developed and still unpublished;

3. Facilitate searching of the literature through deep indexing and other means; and

4. Retrieve specific information on request; i.e., answer on-the-spot questions.

These activities are normally much more closely identified with the research and development programs and the scientific and engineering disciplines than are the document-oriented activities centered on libraries. They require scientific and technical orientation and competence of the participating personnel. Here, too, there needs to be an improved mechanism for really bringing about the desired coordination of effort.

Such, then, are the things that COSATI has done, is doing and will do in the future. We look forward to continued progress in interagency coordination, and to increasingly productive cooperation with the nongovernmental community.

I have highlighted COSATI's development of standards and of uniform practices and procedures. COSATI has also helped create several new governmental organizations which filled obvious gaps in the national information network. COSATI and OST are now planning to help bring about a more effective and efficient national network.

There are some difficult problems to be solved. For example, the advent of national computer-based information systems will raise new issues. Because of the Federal Government's deep involvement in the national effort in science and technology, and because of its close relation to and financial support of the extensive nongovernmental activities in so much of the information network, the Congress will ultimately have to decide what parts of the evolving modern information network and to what degree these parts are appropriately Federal Government responsibilities, and appropriately private enterprise responsibilities. As the report of the President's Science Advisory Committee said:

> Government involvement in scientific communication is going to grow. Can this growth be so guided that user-sensitive non-Government systems are not swamped by elaborate Government systems?

Other difficult problems are the sources and mechanisms for financial support for the information network.

Federal agency information services are usually subsidized by the general taxpaying public for the benefit of the users of the service. This is sometimes justified on the grounds of eliminating the costs of billing and collection of charges for many small items; sometimes on the grounds that more use is encouraged if the services are provided free; sometimes because it is judged to be for the general welfare. It is common experience that people generally associate value with cost to them, and in most cases people are willing to pay for something they really need.

In the absence of a cost-controlling mechanism, an information service like other services, is likely to become unwieldy and cumbersome and unresponsive to user needs. Such a situation could lead to overemphasis on the production or processing side, and to under-

emphasis on the true needs of the user, which is the marketing side. A mechanism by which the users of an information service are made to pay a substantial fraction of the costs for the service is a valuable control device. It also acts as a spur to the information service managers.

There are other serious problems, too, such as the lack of adequate skilled manpower to man the modernized information network, and the lack of adequate information facilities on our college and university campuses, where the future users of the system are being trained.

But the one problem demanding our greatest attention at present is the problem of creating a permanent mechanism for insuring the effective and efficient management of the vast, far-flung, almost incredibly complicated series of functions which together make up the national information network.

As Dr. Hornig testified earlier, such a permanent mechanism probably must be outside of the Office of Science and Technology, as presently conceived.

There are a number of mechanisms which have been proposed in the past few years by people, both in and out of the Federal Government. Let me mention a few possibilities for a central management mechanism. These are: a Comsat-like corporation deeply involved in the actual operation of the information network, with both governmental and private interests; a new Federal agency managing all agency scientific-technical functions, much as the General Services Administration handles other services; a new Federal agency restricted to top-level planning and evaluation, with existing agencies continuing to manage their internal information systems; the assignment of top-level planning and evaluation functions to an existing Federal agency; or a continuation of the present multifaceted management.

These possibilities, and others, are now being examined closely by the COSATI task group and the System Development Corp. I hope that we will have some solutions to this problem within the next few months.

Mr. DADDARIO. Could you go into the relationship of NSF to this entire problem of information? Where does it fit in? How does it fit in with COSATI and OST? What are the lines of communication that exist with relation to it performing its functions with regard to the providing of information?

Mr. KNOX. First, NSF is a member of COSATI. It also operates, as you well know, the Office of Science Information Service.

Mr. DADDARIO. What is its membership?

Mr. KNOX. It is one of the members or COSATI. We can show you who the other members are. There are 10 agencies who are members of COSATI, and NSF is a member like other agencies, just as the AEC, DOD, HEW, and other departments and agencies are members. It has no preferred status on COSATI, if that was a question that you were raising.

In the short time that I have observed at close range, the operations of the Federal information systems, I have certainly been impressed

by the effectiveness of those information systems which are directly related to the mission of the agency or department. I have already referred to the National Library of Medicine. There are other agency systems that are also oriented to that agency mission, such as the Defense Documentation Center, the National Library of Agriculture, and the information programs of NASA and the AEC. If—it is an "iffy" question—if one were to carry this analogy into the National Science Foundation, one might describe an appropriate information mission for the NSF somewhat like this: To insure modern, healthy information systems required to support basic research and education in sciences and engineering.

In other words, tie the information requirements closely to the other missions of the Foundation. This need not be NSF's only information mission.

Mr. DADDARIO. Let me put it this way: Back in 1958, PSAC in their report called for the creation of a unified, efficient, and comprehensive scientific information service with NSF playing a coordinating role.

In a January 1959 letter, in an Executive order, the President asked NSF to assume responsibility for a Federal coordinating plan.

Does the transfer of the coordinating activity to OST in 1964 and the present OST leadership, as you have explained it, today reflect a lesser role for NSF? I think you have already indicated that it does have a lesser role in just being one of the members.

Shouldn't it have a more important function because it does perform a basic research and education function, and, of course, information transfer from that point on does become important?

Mr. KNOX. If I might just comment, or refer back to the testimony, one of the possibilities that is certainly under consideration would be the assignment to an existing Federal agency of increased responsibilities in the top-level planning and coordination of this complex of information systems. The Science Foundation would certainly be a candidate, and a very serious candidate—contender, let's say—for that kind of responsibility.

Mr. DADDARIO. What you have said indicates that the National Science Foundation was a very prominent member in the Government's activities, insofar as information is concerned, then slipped from there to being just one of the members on the Committee on Scientific and Technical Information, and now it is envisaged as being one of the agencies that might be considered. So it has gone a long way from being an important part of this kind of an operation.

I wonder if this is good or bad?

Mr. KNOX. Mr. Chairman, I don't know that NSF has, in fact, slipped, as you have described it, along this path. The Office of Science and Information Service was brought into being by the Congress at a time when the agencies such as AEC and the Department of Defense had very large ongoing information programs, spending tens of millions of dollars a year on them. Asking a sister agency to coordinate, to evaluate, and to plan the activities and information programs of these other agencies, when it had no established competence in the field, was asking it to perform a very difficult task. The reassignment of the overall Federal Government coordinating role in this area to OST, in connection with the Reorganization Plan No. 2 in 1962, was in recognition of the difficulties that might have

been expected in asking a sister agency to coordinate very large on-going information programs of the other agencies.

Mr. DADDARIO. But not impossible?

Mr. DAVIS. If the gentleman would yield?

Mr. DADDARIO. Mr. Davis.

Mr. DAVIS. It reminds me the job that GSA took over, when GSA decided to attend to the housekeeping needs of most all the other Government agencies. Wouldn't you say it has a parallel there? It may not be very close, but it was a similar problem.

Mr. KNOX. We are talking, I believe, in the information systems area, about an operating problem, an on-going operation, which is different, I believe, in type and in degree, from the other substantive programs of the Foundation, which are basic research and the support of education and engineering.

NSF, at the time OSIS was created, was not a very large agency and it was not in effect a competitive operating agency with these other sister agencies.

Mr. DADDARIO. It is the assumption because they were small, they were incapable of doing it?

Mr. KNOX. No. I did not mean to say that.

Mr. DADDARIO. The question comes up as to why should they not have been given that particular opportunity. We can go into that.

Mr. Vivian, do you have one quick question?

Mr. VIVIAN. I have a brief observation.

I would gather that OST did not have a large staff trained in information systems at the time it was not given to NSF because it did not have a large staff trained in the activities.

Mr. KNOX. OST was not in existence at the time.

Mr. VIVIAN. That could not have been the reason for it, per se.

Mr. DAVIS. May I ask a short statement of what the Systems Development Corp. is?

Mr. KNOX. It is one of these nonprofit think factories. I will be glad to supply you with some information.

(The information referred to is as follows:)

Systems Development Corp. is a nonprofit corporation which has specialized in information and data processing and in training for advanced technological systems. Although most of its work has been with the Department of Defense it has also served a number of organizations in the Federal Government and some State and local governments. Last year it served over 100 different government customers and did about $50 million worth of business. SDC has had a quite extensive research and advanced development program in information processing, computer programing systems, and natural language handling.

Mr. DADDARIO. Mr. Knox, we will submit additional questions to you.[1]

If it is at all possible, we will arrange for you to come back here some time before these hearings are closed. This is a very important subject in which you are involved, and you are in an excellent position to give us your views because of your involvement with this in the private sector and in your present capacity.

I want to thank you and Colonel Aines for coming.

This committee will adjourn until tomorrow morning, at the same place, at 10 o'clock.

(Whereupon, at 12:20 p.m., the subcommittee was adjourned to reconvene at 10 a.m., Wednesday, July 28, 1965.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

WEDNESDAY, JULY 28, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee), presiding.

Mr. DADDARIO. This meeting will come to order.

Our witness this morning is Dr. Thomas F. Bates, who is science adviser to the Department of the Interior.

Dr. Bates, we want to welcome you here and thank you for coming back again. You were at the meeting when we had to adjourn at 11 o'clock. We have the same situation today, but since you are the only witness, we are in good shape for this morning's hearing. We are anxious to hear what you have to say.

STATEMENT OF DR. THOMAS F. BATES, ASSISTANT AND SCIENCE ADVISER TO THE SECRETARY OF THE INTERIOR; ACCOMPANIED BY HOWARD H. ECKLES, ASSISTANT TO THE SCIENCE ADVISER; JULIAN W. FEISS, STAFF GEOLOGIST, ASSISTANT SECRETARY FOR MINERAL RESOURCES; AND ARTHUR B. JEBENS, DIRECTOR, DIVISION OF MANAGEMENT RESEARCH, DEPARTMENT OF THE INTERIOR

Dr. BATES. Thank you very much, Mr. Chairman.

Mr. Chairman and members of the subcommittee, it was on June 1 of this year that I became the science adviser to Secretary Udall in the Department of the Interior. Prior to this, for the past 23 years, I have been a professor of mineralogy at the Pennsylvania State University. I believe you heard my honored chief speak before you yesterday, President Walker.

My most recent positions there were director of the Institute for Science and Engineering, assistant to the dean of the Graduate School, and assistant to the vice president for research.

You will see from my background that at this point in time I can speak from personal experience more adequately about relationships between NSF and the universities than between NSF and Interior.

However, in preparation for this hearing we have tried to make a thorough study within the Department as to the relationships which I wish to speak about this morning and the problems related thereto,

and I sincerely believe that the statement accurately represents the attitudes of the best scientists and research administrators in the Department. I personally am very pleased to have the opportunity to present it to you, and I would like to introduce to the members of the committee, Mr. Eckles on my left, who is the assistant to the science adviser, Mr. Julian Feiss to my immediate right, who is a staff geologist in the U.S. Geological Survey and attached to the Assistant Secretary for Mineral Resources, and Mr. Arthur Jebens, who is the Director of the Division of Management Research.

Mr. Daddario. The committee is happy to have all you gentlemen here.

Dr. Bates. I am sure that if there are detailed questions regarding the Department you will find these gentlemen more expert than I because of longer experience there.

In order to provide the committee with appropriate background information, I would like to preface my remarks on the Department-NSF relationships with a brief statement as to the Department's present and future role in the research activities of the Nation.

I think this will serve as important backup material for an appreciation of some of the points with regard to NSF-Interior relationships.

As you know, the Interior Department has many units within it, each charged with specific and somewhat different responsibilities. In a general way, however, the role of the Department as a whole can best be described as that of a technical consultant and trustee with respect to much of the natural wealth of the Nation: its minerals and metals (including the all important uranium and thorium); its coal, oil, and gas; the waters of its lakes, rivers, streams, and off its coasts; the fish that live therein; and the wildlife population that inhabits the land. Obviously, if the Department is to be the right kind of consultant and trustee, it must act on a fully informed basis of scientific and technical knowledge and in relationship to long-term, national interests. In those cases where the resources are renewable, as in water, fish and wildlife, the responsibility must involve every possible action that can be taken to maintain or even expand the supplies to meet new requirements. On the other hand, the expendable wealth—minerals, metals, and fossil fuels—must be recovered, beneficiated, and utilized with maximum efficiency and at minimum cost, taking full advantage of technical developments, alternative sources, or development of substitutes.

Finally, since the full extent of our potential natural resource estate is not known, and indeed changes in value as a result of advancing technology, the Department has to be engaged in a continuous process of exploration and evaluation and be aware of new developments in all related fields.

Figure 1 illustrates that, relative to Federal R. & D. expenditures in other areas of national concern, the natural resources program takes a back seat as far as Government funds for research and development are concerned. Although basic and applied research in industry on minerals, metals, petroleum and other natural resources adds approxi-

RELATIVE FEDERAL SUPPORT OF RESEARCH AND DEVELOPMENT BY SELECTED FUNCTIONS

FISCAL YEAR 1964

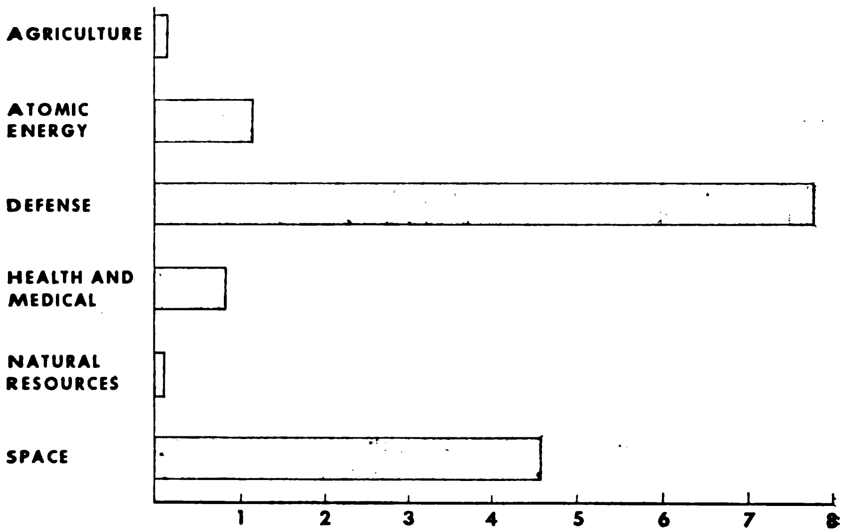

FIGURE 1

mately another $0.6 billion most of this is for short rather than long-range research. One can't help but wonder if we are sufficiently concerned about our basic wealth and our source of income and how to guarantee and, if possible, increase it for future generations, as compared with how we spend this income.

As the Federal agency having the greatest responsibility for the discovery, recovery, and—where possible—renewal of our natural resources, the Department of the Interior cannot properly discharge its obligations without being immersed in research activities of all kinds: applied and basic, in-house and extramural, laboratory and field, modest and expensive. Part of its responsibility is to develop ever closer and more effective relationships with all individuals and groups that can help it to carry out its many missions: universities, industries, other mission agencies and certainly the National Science Foundation.

The present research program of the Department, as might be expected, varies considerably in character and amount of funding from bureau to bureau. This variability is illustrated in figure 2 which shows the total research expenditure of each bureau and the in-house versus extramural proportions. It will be noted that three of the four bureaus with the largest research budgets spend the money largely in-house, whereas the three most recent additions to the Department; namely, the Office of Water Resources Research, the Office of Coal Research, and the Office of Saline Water, rely heavily on extramural research and development groups in helping to accomplish their missions. The amount of extramural funding that goes to universities is shown with other data in table 1.

DEPARTMENT OF THE INTERIOR
OBLIGATIONS FOR RESEARCH AND DEVELOPMENT BY IN-HOUSE AND EXTRAMURAL PERFORMERS
FISCAL YEAR 1965

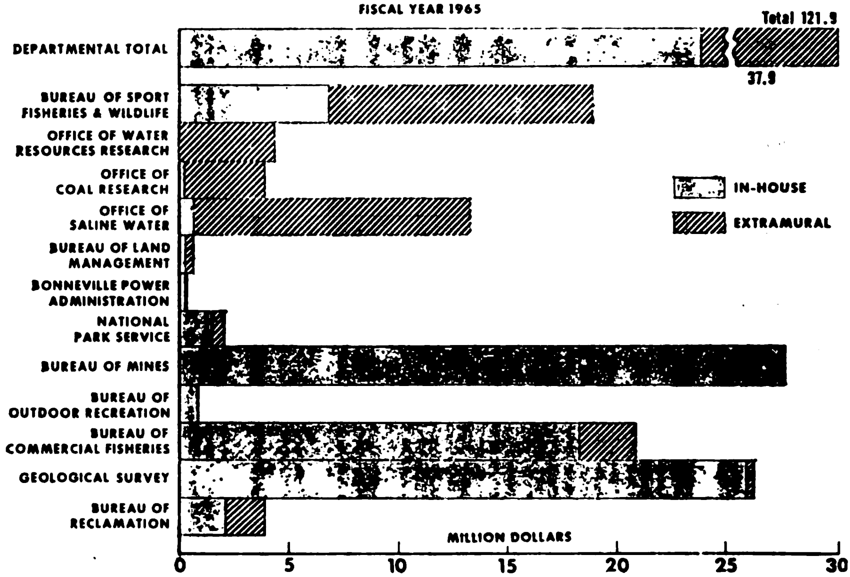

FIGURE 2

DEPARTMENT OF THE INTERIOR

TABLE 1.—*Obligations for research and development by performers, fiscal year 1965*

[Thousands of dollars]

Bureau	In-house	Universities	Nonprofit	Industry	Other
Commercial Fisheries	18,096	1,611	369	----	340
Reclamation	2,180	803	----	----	425
Geological Survey	26,606	300	----	----	----
Outdoor Recreation	73	1	----	----	----
Mines	27,645	5	----	----	----
National Park Service	1,389	376	169	----	25
Bonneville Power Administration	211	114	----	----	----
Land Management	254	361	----	----	----
Office of Saline Water	631	2,400	100	10,376	110
Office of Coal Research	15	296	850	2,731	----
Office of Water Resources Research	----	4,276	----	----	----
Sport Fisheries and Wildlife	6,939	400	33	8	11,443
Departmental total	84,039	10,943	1,521	13,110	12,343

It would not be appropriate at this time to go into detail as to the Department's present research program and specific plans for the years ahead. With the chairman's permission, however, I would like to enter into the record at this point a copy of a letter from Secretary Udall sent in answer to a request from Mr. Daddario last fall to provide a brief description of program areas scheduled to receive major emphasis in the Department. This discussion included statements on numerous activities grouped under the headings of: Water resources, energy resources, minerals and geology, land resources, fish and wildlife resources, ocean resources, and ocean engineering. As this letter pointed out, the ability of the Department to implement properly the desired programs will depend in part on the successful resolution of

certain key issues some of which, such as relationships with universities, are very pertinent to these hearings and will be mentioned later.

(The letter referred to follows:)

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
Washington, D.C., November 12, 1964.

DEAR MR. DADDARIO: In further response to your letter of July 29, 1964, we are sending you a brief description of projects which will receive major emphasis in our scientific research and development program during the years ahead. This research includes many significant programs now underway in the Department to improve the national capability for development and conservation of natural resources. Through rescheduling of efforts and addition of new programs at the request of Congress, there will be increased research on water resources, ocean resources, and environmental pollution as it pertains to welfare of fish and wildlife.

We have organized our information on research under categories of water, energy, minerals and geology, land, fish and wildlife and ocean resources and engineering. As we view development of this program, key issues become apparent and these are described in the final paragraphs of this letter. These issues will need to be resolved if the research program outlined is to have its maximum effect on the Nation's resource development.

WATER RESOURCES

Investigations in significant areas will be continued to elucidate hydrologic systems, provide basinwide water resources appraisals, provide information on ground water resources and other data for use in all types of water management.

There will be research on hydrologic principles and observational techniques. This includes studies of the hydraulics of water, movement, storage and flow in channels, lakes, glaciers, and in the ground, chemical reactions of water with aquifer materials, processes of evaporation and transpiration, processes of sediment transport in rivers, and hydrologic effects of man's activities.

Nationwide water data networks will be strengthened to obtain facts about the stage, flow, chemical properties, sediment content, and temperature of surface waters, and to monitor natural and manmade changes in ground water conditions. This includes depth to the water table and chemical quality of ground water.

There will be a program of research and training of scientists through the Water Resources Research Act of 1964. Water resources research institutes or their equivalents will be established in the States and Puerto Rico. Matching grants for research will be made to these institutes over and above a basic allotment provided by the act. Grants or contracts will be made to other research organizations and water resource agencies, including educational institutions that do not have established institutes. This program will be responsive to State, regional, and local water resource needs and to the use of multidisciplinary talents for meeting those needs.

Saline water conversion will be elevated to a new level of effort. We will substantially increase research to develop entirely new desalting techniques, to improve distillation processes and to develop the promising reverse osmosis process.

Development of large multistage flash evaporators for saline water conversion will be accelerated by a program of conceptual design studies to encourage new approaches and by building and testing modules to encourage new approaches and by building and testing modules and components. It is anticipated that research and design advances will justify construction in the late sixties of at least one dual-purpose plant in the range of 50 million gallons per day, using the multistage flash distillation process.

Weather modification is to be studied with the aim of increasing water supplies over water storage projects used for agricultural purposes and power generation. This will involve study of cloud seeding, particularly during winter storms rising over the Rockies. The objective is to increase snow pack and eventual runoff into storage reservoirs. This is to be a cooperative effort with other governmental agencies and universities having an interest and competence in weather modification research.

ENERGY RESOURCES

The fossil fuels, coal, petroleum, and natural gas which will supply the bulk of the Nation's energy supplies will be the subject of major research efforts. In addition to research to improve known detection and extraction methods, projects will be undertaken to develop new uses and techniques or to overcome particular problems hindering wider use of coal and petroleum. Among these will be efforts to convert coal to gaseous fuels, produce gasoline from coal, and develop a coal-fired gas turbine suitable for generating electricity in central-station coal-burning powerplants.

During the next several years research will be intensified on developing new means of producing petroleum and natural gas from low-permeability problem reservoirs by use of chemical and nuclear explosives and by use of unconventional supplemental energy sources.

Methods will be developed for determining causes of air pollution by automotive engines and of preventing such pollution. Problems of the stability of petroleum fuels in storage and in use under adverse conditions will be studied. Information will be obtained on the composition and utilization of heavy fractions of petroleum, particularly asphalt. Thermodynamic properties of numerous sulfur, nitrogen, and hydrocarbon compounds will be determined to provide basic data needed for air pollution and other research.

There will be fundamental and engineering research on oil shales. This will include determining the occurrence and properties of oil shales, the physical and chemical make-up of various shale oils and factors involved in converting the solid kerogen; i.e., oil shale, to oil. This will include experiments in in-situ extraction, a potentially improved method which eliminates mining of the shale before extraction of the oil.

Investigations are to be made into numerous opportunities in the energy field including those which use fossil fuels where increasing efficiency or supplying energy by new methods might lead to more abundant overall energy supplies. Particularly, there are opportunities to supply energy where the demands are unique. Included are the use of solar energy, development of fuel cells, further research and development in application of magneto hydrodynamics. Research and development is to be continued on extra high voltage transmission of alternating current and the use of direct current transmission for electrical energy transport over long distances.

MINERALS AND GEOLOGY

Research will be conducted to improve the Nation's mineral resource base. Basic geologic data and interpretations will be provided through reports and maps of adequate detail for appraisal of resources and determination of resource policy. This will also assist private enterprise in its search for mineral raw materials and its use of land such as for highway construction and urban and engineering developments.

Other research will be on geologic, geophysical, and geochemical principles and processes. This will provide new knowledge for exploration of hidden mineral resources, prediction of earthquakes and volcanic eruptions, and application of geology to space exploration, engineering problems, underground nuclear explosions, communications, and oceanography. Several of the research activities are expected to be reinforced and amplified by efforts of other scientific organizations in this country and abroad being coordinated under the international upper mantle program.

Mining engineering research will cover a wide scope and will be directed to translation of research results to engineering principles applicable to mining. An important phase is adaptation of mathematical tools, techniques of statistical analysis and operations research to mining problems in sampling, quality control, and systems analysis. An important segment of this area of research is large-scale field investigations under operating mine conditions to test the validity of developed theory and establish the parameters essential for engineering application.

Problems of waste material utilization especially iron and steel scrap are becoming more formidable as the accumulation of scrap automobile bodies mushrooms in junkyards throughout the land. Metallurgy research is underway to provide an economic solution to this vexing problem.

LAND RESOURCES

Research and investigations will be carried out to support management operations on public lands administered by the Department. Included with this will be related programs for the national parks and research to meet outdoor recreation planning requirements.

Research for public land management will concern a variety of disciplines and will be on soil and watershed problems, range, wildlife, forestry management, and resource use and protection.

A major effort in the national park system over the next several years will be research in environmental biology and ecology to preserve and manage natural areas of the parks. Practical problems in the maintenance of natural areas are resulting from access roads, visitor traffic throughout natural areas, fauna and flora changes in response to man's activities and natural evolution. Research is needed to gain information with which to interpret the results of the interaction of these forces and to form a basis for the design of future actions for park management and preservation. This research program which is relatively small at the present time should grow to be one of the principal research efforts within the Department over the next several years.

In the field of outdoor recreation, research is needed on a variety of subjects which will form the basis for the overall design and coordination and communication about national outdoor recreation systems. Included as subjects for research are the expected supply of recreational resources and facilities, current and future predicted demands, the effects of recreation on people and on society, the economic impact and results of allocations of lands and water areas among competing uses, and the Federal, State, and private roles in providing outdoor recreational opportunities.

FISH AND WILDLIFE RESOURCES

Major emphasis in research on fish and wildlife resources will be on pollution and its effects on the welfare of fish and wildlife. Problems of environmental alteration and pollution are becoming more acute as urbanization and industrialization progress. Many streams, lakes, estuaries, and inshore coastal areas which are all important to the production of aquatic species are polluted to some degree with wastes and pesticidal chemicals. It is known that pesticides and many types of industrial wastes can kill fish and shellfish in minute quantities. Present indications point to a continued increase in pollution problems and the need for major efforts toward an understanding of pollution and devising means for its abatement is needed. Expansion of effort in this field is planned.

Biological research is planned to ascertain the underlying reasons for decline in the abundance of certain fish and wildlife populations and to develop knowledge for forecasting future fluctuations. Studies are to be conducted also on the impact of natural and manmade changes in the aquatic environment. This research will include measurements of the abundance and survival rates of young forms, the effects of harvesting intensity and considerations on the type of harvesting methods used as they relate to attaining the most desirable production of commercial and recreational species.

A new opportunity in the field of food fish production is the possibility of aquaculture applied in large outdoor impoundments or in natural situations. Accomplishment of artificial production will involve further studies of both fresh water and marine species to gain an understanding of genetics and physiological and biological requirements. There will also be needed prototype facilities for water control and creation of facilities in enclosed bays, channels, and streams. The artificial culture of fish is one means whereby production levels can be maintained and possibly increased in the face of a changing environment through engineering and pollution.

OCEAN RESOURCES AND OCEAN ENGINEERING

The Department's program in oceanography and ocean engineering is scheduled for continuation as planned through the Interagency Committee on Oceanography. This will involve studies of the ocean environment to support an increased harvest of marine food and game fishes. Research on other types of marine resources will concern marine geology, hydrology, and the development of a marine minerals technology.

There will be a substantial program of support to States which results from the Commercial Fisheries Research and Development Act of 1964. Under this act Federal funds will be made available to supplement State funds on an approximately 75 percent Federal, 25 percent State formula. Research and development is to be carried out by States which will aid all aspects of commercial fisheries.

Increased attention is to be given to application of oceanographic knowledge to ocean resources development. This will include geological information as a basis for construction of coastal installations, the development and use of specialized underwater craft for marine mineral and fishery explorations and the development of new techniques for fish detection, harvest, and processing.

KEY ISSUES

Inherent to the development of the preceding programs are a number of general problems. The manner in which these problems are met will have a significant bearing upon the future course of the individual research programs.

(a) *University and industry relationships.*—The research programs of Government do not stand alone. It is important that the best talent be applied to any of the research problems that are encountered, and often the needed research competencies are in university or industrial organizations. This Department has been oriented to in-house research and development work with a minimum of contracts, grants, or other arrangements with extramural groups. Mechanisms must be found to reorient the research program to greater extramural effort. This will involve consideration of grant programs to universities, contracting authority for bureaus of the Department, campuses, the education of needed resources specialists, and many similar problems.

(b) *Information centers.*—It is important that there be some centralization of information about resource fields so that the Nation can be assured of total overall research plans which will be responsive to the Nation's needs. To bring such plans into being, to evaluate and coordinate research progress, and to apply the results of research to the national needs, it is necessary that information flow exist. Information centers will need to be established. It is not clear how many such centers are needed or how they should be organized. It is clear, however, that the need is pressing in all resource areas. The Department, with its basic obligations for research and resource development in such fields as geology, minerals, aquatic life, energy, and outdoor recreation and with its program scope related to regional and State problems as well as to national problems must find means for establishing information centers that will fill these needs.

(c) *Research in resource analysis.*—A need for information centers is paralleled by a need for analytical groups concerned with resources. Such research groups would study the methods of resource analysis, apply latest technological techniques to analyzing resource needs, and evolve national plans. Resource analytical groups should be part of river basin planning, regional water programs, energy utilization, regional interties, environmental pollution, and similar activities. They need to combine the best research talents from economics, sociology, and environmental behavior, as well as from the biological, physical, and engineering sciences. Some resource analysis research can be done within the individual resource areas, but there are broad principles which apply to any type of resource analysis. These would receive the attention of a broad departmental group.

(d) *Ecological survey and research.*—It is more and more evident that resources are tied together from an ecological point of view. What is done in one area of resource development will have an impact on another. Furthermore, our basic ecological system is not well understood. We must gain a complete base of understanding about our ecology before it is further altered or destroyed. Within the ecological system, there are many gaps that have never been examined thoroughly, such as the community of plant life or the community of animal life. Neither of these have ever been adequately surveyed. Just as we have the Geological Survey to carry on basic measurements and analysis of the earth's mantle, so we should extend this same principle to the things that live on and in the earth—its plants, its animals, and the manner in which they are interrelated. In short, we must know our environment and its ecological relationships before we can consider alternatives for changing our environment and altering man's place in it.

(*e*) *Ocean operational capability.*—Research that will enable us to exploit the ocean for food, minerals, energy, recreation, and fresh water, as well as research directed toward a basic understanding of the geological processes allied with the ocean, require an ability to move around in, to make measurements on, and to do all sorts of operations within the ocean. A chief limitation to the development of ocean resources research and to applications that will advance our use of the ocean rests in our inattention to this operational capability. It is important that the Department acquire an operational ability for ocean work. Research appropriations that might go to active research often go to the increased costs of running or supplying ships or to the development of underwater craft. With its many mission fields concerned with the ocean, it is quite important that the Interior Department be able to coordinate this activity at the level of an operating capability. The form which this takes is yet to be determined. It will probably involve the sharing of shore bases by a number of research bureaus and a common use of oceangoing facilities. It should provide a common operating capability for use of all researchers who have a mission in the environment.

Sincerely yours,

STEWART L. UDALL,
Secretary of the Interior.

Dr. BATES. Now, if I may speak specifically to the matter of NSF-Interior relationships, I would first like to point out that the degree of association varies considerably from one part to another of the Department. At one extreme are groups like the Bureau of Land Management and the Bureau of Outdoor Recreation which have very little contact with the Foundation. At the other are, for example, the Bureau of Commercial Fisheries and the U.S. Geological Survey which have a great many ties ranging from personnel participation on reviewing and advisory panels, the use of NSF-funded facilities, and many others. As another example, the Office of Saline Water has a formal arrangement with the Foundation providing for liaison regarding proposals of mutual interest, where these proposals are sent back and forth and reviewed by both groups.

A quantitative indication of the common concern of the two groups in certain general subject matter is given in figure 3. Strength in the biological sciences is focused in the Department in the Bureau of Sport Fisheries and Wildlife and in the Bureau of Commercial Fisheries.

The situation in the behavioral and social sciences should be mentioned primarily because of the rapidly emerging importance of such areas as animal behavior in the areas of fisheries and wildlife, and of human resources studies in connection with land management, outdoor recreation, and the future of our national parks. General similarity of concern and responsibility in the physical and engineering sciences is evident from the figure and exists, of course, because of the nature of the missions of the U.S. Geological Survey, Bureau of Mines, the Office of Saline Water, the Bureau of Reclamation, and other groups. It is within the scope of the life, physical, and engineering sciences that Interior and the NSF could benefit from an expanded program of consultation and interaction in shaping the cooperative research and training programs.

In our opinion NSF-Interior relationships are characterized by the following areas of effectiveness:

1. The use by NSF of Interior scientists for proposal evaluation and, in a few cases, as members of advisory panels. The Department has also turned to NSF personnel for similar assistance.

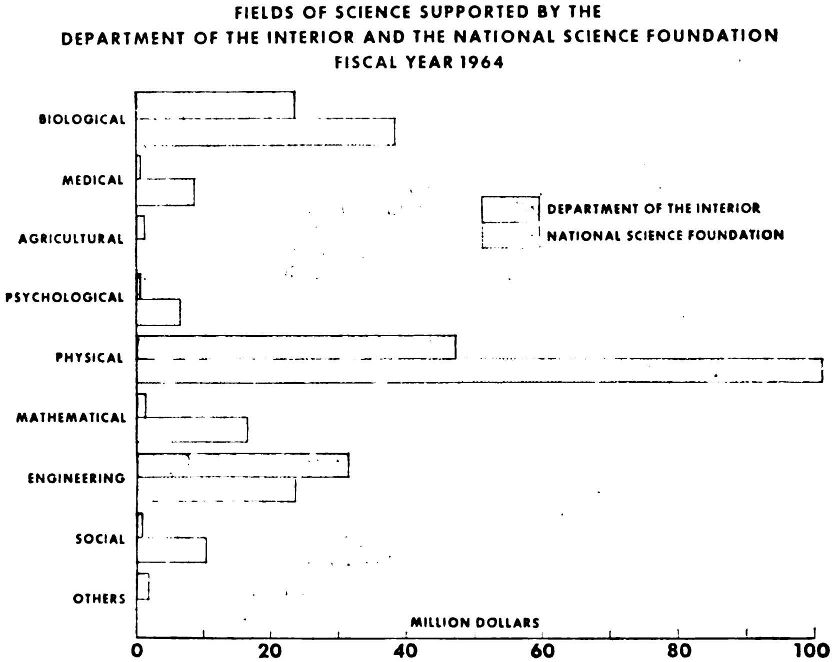

FIGURE 3

2. The availability of NSF-provided special facilities such as oceanographic vessels.

3. The availability of data collected and collated by the NSF on the many aspects of the state of science and scientific manpower in the United States.

4. Interaction through coordinating committees; for example, the Interagency Geophysical Discussion Group, the Interagency Committee on Oceanography, and so on.

5. Participation in NSF-supported programs such as the U.S. Antarctic research program and the United States-Japanese cooperative science program.

6. Some attendance of Interior scientists at NSF-sponsored summer institutes and in a few cases where NSF fellows, both postdoctoral and predoctoral, have done their research in Department laboratories.

In the areas where these relationships exist, they are cordial, close, and advantageous to the Department. One major need is for more of them.

In the opinion of Interior research administrators, areas presenting problems are (1) communications; (2) lack of sufficient research support in areas of major concern to the Department; (3) a tendency of the fellowship and trainee programs to attract the best students away from the areas and problems challenging the Department; and (4) lack of a management policy that attempts to assure adequate coverage of all science areas from the standpoint of the research and manpower that is needed.

The problem of communication is listed first because improvement in this area is essential to the solution of all problems in our opinion.

By communication is meant the development of a working partnership; not simply getting together for lunch. The present situation, as viewed from Interior eyes, is somewhat as that pictured in the oversimplified diagram below where the Foundation, Interior, and the universities are at the corners of a triangle enclosing the basic research goals of common interest to all three. The excellence of the working relationship between the NSF and the universities is symbolized by the solid line connecting them. Communications between the Department and universities is spotty—very good in places, poor elsewhere—and efforts are being made to move from a dashed to a solid line relationship here. The areas of effective NSF-Interior interaction mentioned earlier are only sufficient in number and size to justify a dotted line.

The situation might be compared, by a simple analogy, to that of three hunters with nets trying to close in on a wild animal, which in our case represents the research objectives. If we are going to capture the animal, this means perfectly coordinated teamwork and no holes in these nets. We need betters coordination and a tighter net between Interior and both its other partners, particularly NSF.

Mr. DADDARIO. Dr. Bates, you refer to better communications and say a working partnership ought to develop. Do you mean that before informal relations between one agency and another can develop in a fruitful way, that there must first be a formal setup which establishes a relationship from which informal relationships can then be helpful? In this instance you do have some informal activity, but not enough formal communications between the two agencies.

Dr. BATES. I think it is natural in the way of things that the informal relationships tend to develop first and lead to more formal ones. I think we have a great many informal relationships between these two organizations. Possibly, however, we need still better informal relationships at high levels in order to subsequently have more formal relationships at high levels.

Mr. DADDARIO. Many other witnesses have indicated that they have good formal relations, but that the informal activities are probably more important. In your case, there seems to be no base upon which to work.

Dr. BATES. I think it is the other way around in our operation. I don't think there are nearly enough formal relationships that have as yet been established, and probably not nearly enough informal ones either. I believe we need working committees with assignments to look at the areas of research that are of common and mutual concern to the Science Foundation and the Department of the Interior. These committees would first presumably evaluate where the gaps are in these research areas and presumably should have ideas as to how they might better be covered by Federal funding and also by better relationships between the two groups.

Mr. DADDARIO. If there is this desire for such interaction, what has prevented it?

Dr. BATES. I think it is simply the fact that both groups, in the usual situation where they are bound by limited amounts of funds, have very specific missions that require that they move in certain directions—relative to universities in the case of NSF, relative to certain specific missions in the case of Department units such as the

Bureau of Mines and the U.S. Geological Survey. The funding has not been sufficient to cover the total area of the research spectrum from fundamental research as represented by NSF and applied research as represented by the Department of the Interior. We have at present two peaks, one at the Interior end and one at the NSF end of the question. Both of these peaks need to be broadened at the base into pyramids which join on a common base even though the peaks of specific interest and responsibility are separated. I noticed, Mr. Chairman, that you pointed out during Mr. Ripley's testimony that other witnesses have made this same point with regard to the need for NSF to move closer to the other agencies and vice versa. I am in agreement.

Mr. DADDARIO. When funding is scarce, NSF has moved closer to the other agencies, and they seem to get along better. You are in that situation without having had the opportunity for larger funds previously. There should be a closer relationship so that the funds could be better utilized. You have indicated a problem because some of the fellowships and grants attract people away from subjects in which you are interested. Since this is the case, there would seem to me to be a special need for a closer relationship so that this could be worked out.

Dr. BATES. I agree. I think that is the main point I am trying to make that we should have people who are formally charged with discussing the grant programs of the National Science Foundation——

Mr. DADDARIO. It is not the lack of funds which keeps you apart actually although there seems to be an indication that this is the reason why you are apart. The move has not come, and it ought to.

Dr. BATES. I agree, it certainly could have come even though there haven't been any more funds than have existed in the past. Let me say here, however, that I don't want in any way to make derogatory implications about the past role of the National Science Foundation. I think this is a two-way street in which there is a need for a great deal more work on the part of both groups involved. I don't think the past relationships have been at all unpleasant or illogical, but I think we can move into the future by bringing these two important units of our Government closer together.

Mr. DADDARIO. Was the reason there has not been better coordination because of the fact that sufficient effort has not been made in that regard or because your major activities normally have been in a different area?

Dr. BATES. I think both these factors are very important. I must admit that the situation is of great personal interest to me. In much of my scientific as well as administrative work in the university I have been in close touch with various NSF programs and, as a consequence, I feel pretty well informed on NSF-university relationships. In the month and a half I have been in the Department of Interior I have been impressed with the close relations between individuals in the Geological Survey, for example, and the Earth Sciences Section of the Foundation. I am also impressed, however, with the lack of knowledge in many units of the Department of Interior as to exactly what the NSF is trying to do, what its programs are, and what its aims are relative to Interior's objectives. There appears to be a lack of communication that exists I think, because of the natural tendency for each Federal agency to take care of its own operation. I should add at this point that I have been very impressed with the activities of the

Federal Council in working on exactly this problem of bringing the agencies closer together.

Mr. DADDARIO. Can you see at the present time a good opportunity to do this?

Dr. BATES. Tremendous opportunity, one reason being that the Department of the Interior is trying to move more strongly into areas such as improved Interior-university relationships, which will automatically bring them closer to the NSF also.

To continue with my statement, problem areas (2) and (4); namely, lack of research support in some areas and lack of management policy to assure complete coverage in science, both exist because of NSF's reticence—up to now, perhaps, a proper one—to assume sufficient leadership in or to even press for science management within specific areas of science. NSF coverage of research in any given field is determined by the nature of the proposals that are submitted and approved. For better or worse no organized or directed attempt is made to assure representative coverage or to orient the research participation. The university researchers who submit proposals acceptable to panels, those panels being composed largely of other university scientists, determine how well that field of science will be covered, during the period involved, by NSF-supported basic research. Gaps or imbalances in the coverage may or may not be noted, and even if recognized, do not stand much chance to be corrected while this system operates. Such a policy makes it difficult to relate NSF-supported research to agency programs and objectives, particularly when communications between the three parties is, in our opinion, inadequate.

In the scientific manpower area there is real concern among Interior's top research administrators that NSF and other fellowship programs influence students in the direction of basic rather than applied research, thereby making it increasingly difficult for mission-oriented agencies to obtain top talent. In this regard, the emphasis on trainee programs is welcomed as an indication that some degree of management is being applied to assure a more equitable distribution of funds among subject matter areas.

With the full realization that the problems cited above are difficult and of a long-range nature, the following areas of improvement are indicated:

1. Improve communications by establishing NSF-Interior coordination and planning groups charged with the recognition and solution of problems affecting the progress of science in areas of mutual concern.
2. Set up NSF-Interior-university committees in appropriate subject matter areas charged with the responsibility of reviewing research coverage in the given fields, discovering gaps and imbalances and recommending ways of closing them.
3. Make much more use of Interior scientists on NSF review and advisory panels.
4. Establish cooperative programs involving the use of Interior laboratories and equipment for the training of NSF-supported undergraduate and graduate students.
5. Increase the proportion of traineeships allocated to the departments and interdisciplinary graduate programs operating in the areas of the "environmental" and applied sciences (for example, mining

engineering, metallurgy, ceramic technology mineral beneficiation, fuel technology, chemical engineering, materials science, regional planning, and conservation).

In conclusion, Mr. Chairman, I should like to make it clear to you and the committee that we in the Department of Interior fully realize that our relation with the National Science Foundation involves a two-way operation in which the Department has a responsibility as well as the National Science Foundation. We are working hard to increase our relationships with universities and can logically look to NSF for assistance in this area. We hope that the Foundation will be in a position to assume leadership in the new directions that we feel science must take in the next 15 years by bringing mission-oriented agencies like Interior together with the universities and the NSF into a comprehensive program of science with fewer gaps and closer communications.

Again, may I thank you for this opportunity to appear before you. I will be glad to respond to any questions that you or other members of the subcommittee may have.

Mr. DADDARIO. Dr. Bates, could you go into a little detail as to the relationship that now exists between Interior and NSF? How does that work? What are the means of communication? What areas can you point to?

Dr. BATES. I think the first thing that impresses me is the number of coordinating activities where members from both groups serve on the various panels that are set up by organizations such as the Office of Science and Technology. There are also an increasing number of areas of mutual concern as, for example, that of United States-Japanese relationships. We have just concluded a second meeting of the United States-Japan Panel on Natural Resources, at which both NSF and Interior were well represented. As another specific example, Interior and NSF representatives serve on the Federal Council for Science and Technology and its various subcommittees such as the Interdepartmental Committee for Atmospheric Sciences. We are working very closely with NSF and other agencies in this area.

The second example of close relationships is that a number of Interior scientists are used to some degree, in the same way as university people, in the review of NSF proposals. There is no inclination, as far as I know, on the part of the Science Foundation to exclude as panel members people from the U.S. Geological Survey, Bureau of Commercial Fisheries, and other Interior bureaus simply because they are in the Government. I feel that there could be more use of our scientists, however.

From the standpoint of the use of the Science Information Exchange and the tremendous amount of data provided by the NSF, such as that that we have tried to use quite extensively in preparing for these hearings, the NSF has done a fine job of providing all mission-oriented agencies with useful backup information on science and matters related thereto.

The U.S. antarctic program provides a very good example. Here is a program for which the National Science Foundation is responsible but where the Geological Survey receives appreciable funding to conduct a large amount of mapping and research. In another case—the Indian Ocean program—NSF oceanographic vessels were used

extensively by Bureau of Commercial Fisheries scientists. The NSF National Center for Atmospheric Research in Boulder has very close ties with people in our Department that are working on meteorological problems. Thus, in many areas such as these we can point to very good relationships between the NSF and the Department of the Interior. There is opportunity for a good deal more interaction, however.

As an example of one type of Interior activity that might involve the cooperation of the NSF or some other foundation, I might cite a program now being planned by the U.S. Geological Survey and the National Association of Geology Teachers where it is hoped that a foundation may be willing to provide support for a certain number of students to attend geology field camps during the first year of their graduate work. The U.S. Geological Survey—on the basis of the results of the students' first year work—would put a certain number of them on WAE (while actually employed) status on their field parties during the following summer in order to move them one step farther toward actual, practical geological mapping.

Similarly we have many Bureau of Mines laboratories scattered throughout the country, many in cities with good universities. We feel these laboratories might relate more closely to departments of mineral beneficiation, metallurgy, chemical engineering, and others in these universities. If we could get an NSF-Interior operation going, where students with NSF support might use the facilities and laboratories of the Bureau of Mines, this would do several things. It would provide both financial and facility support for the student. It would strengthen Interior-university-NSF communication. It would give the students experience in a Government laboratory and a feel of what the needs are in their chosen area of work.

Mr. DADDARIO. Career opportunities and things of that kind?

Dr. BATES. That is correct.

Mr. DADDARIO. Would you go into greater depth on the point you have raised about NSF not assuming sufficient responsibility in science management within specific areas of science?

Dr. BATES. Let me say first of all I realize the word "management" is a rather touchy one to use in speaking of any scientific activity. However, I think we must realize that in deciding that a certain amount of money should go into the physical sciences, a different amount into the engineering sciences, and still other funds into the biological sciences, a management operation is already taking place relative to the balance between the broad areas. What I am suggesting here is that this operation might also be used at a sublevel so that within the engineering sciences, for example, the total funds available would be appropriately divided among the various fields of engineering science. From the standpoint of doing the best for this Nation with regard to total coverage of science, I believe the agencies responsible for providing the funds must make decisions on such questions as: Is civil engineering getting enough support relative to mining engineering, relative to industrial engineering, relative to metallurgy, and so on?

Mr. DADDARIO. You are referring then, to better ways of establishing national goals and objectives and of recognizing the technical levels

available to accomplish those ends, and to the basic choice we make to accomplish these end objectives?

Dr. BATES. Better ways to establish them and as I say to accomplish or meet them. I am impressed by reports like this,[1] which is one of seven reports put out on the general subject by the National Academy of Sciences. This one is on mineral resources, and contains the recommendations of a committee headed by Dean Frasché of the Union Carbide Ore Company. It would not be pertinent to quote all of their recommendations but among them are: that basic research on the chemistry and the physics of the earth's crust should be augmented during the next decade at a rate of 25 percent per annum; that the research program in mineral extraction should be expanded at the rate of 15 percent per annum during the next decade. There are seven or eight such recommendations based on a detailed study of our national needs in the mineral resources area. The point I want to make here is that to meet these needs we must go about it logically, not primarily on the basis of the subject matter distribution of proposals that the scientists just happen to be putting into the National Science Foundation, but in terms of careful fund distribution based on all applicable criteria. The planning involved obviously cannot and should not be the responsibility of the Science Foundation alone, but because of the role the Foundation is playing in American science, it must assume a large part of the responsibility.

Mr. DADDARIO. Mr. Davis.

Mr. DAVIS. Mr. Chairman, I would like to ask a definition or two. In the first place, what does the study of hydrology embrace?

Dr. BATES. I would say all aspects of the water budget, where the sources are, how water flows through the crust of the earth, how it is measured, where it goes, and so on.

Mr. DAVIS. In other words, you are not studying water itself so much as what it does and how it interacts with other things?

Dr. BATES. That is right.

You can't study anything thoroughly without relating it to its environment.

Mr. DAVIS. I have been wrestling with the difference between science and engineering for a good long while, and you use the term "engineering sciences." Just what does that mean?

Mr. DADDARIO. Did you throw that in there just to confuse Mr. Davis?

Dr. BATES. I think the reason for some of the confusion is because of the traditional development of these fields. At Penn State, for example, we have a college of engineering and across the campus, a college of science. There was no confusion as far as I could see 15 or 20 years ago in that there were distinct differences. Most engineers at that time were not getting Ph. D.'s. The scientists were not applying themselves primarily to the day-to-day problems of science at least in Ph. D. thesis-type research although many students subsequently were employed by companies concerned with applied research. The situation has changed tremendously in that it is recognized by engineers that they must now have a much more detailed knowledge of the physics and chemistry related to their chosen area of research

[1] Mineral Resources: NAS–NRC Publication 1000–C, 1962.

and development; whereas the scientists, who appreciate that their basic research may very soon find application, are well aware of the importance of knowing more of engineering. I realize I am not answering your question very directly, but I don't think there is a direct answer in that this is a continuous spectrum which can be talked of in terms of science and basic research at one end and engineering and applied research and development at the other. There is a gray area in the middle where the transition is made from fundamental to applied, and the term "engineering sciences" is used to cover part of this gray area. The increasing importance of interdisciplinary activities where science and engineering combine to work on problems of all types also encourages the use of the term "engineering sciences."

Mr. FEISS. Up until, you might say, a relatively few years ago, I would say about the time of World War II, we had a tendency to compartmentalize engineering from science. Science was considered primarily as the search for truth, the search for the laws of nature that govern various phenomena. That was the definition. Engineering, on the other hand, was the application of those laws to human benefit and human welfare. It became evident I think during the war particularly (you recall the history, for example, of the Manhattan project) that you had to coordinate to a very close degree the scientific findings along with their application. I think that essentially this is where the change in definitions comes about, where the merger takes place you might say.

In other words, it is recognized generally today that science does not exist in a vacuum purely as a search for truth, but that it should be pragmatic, it should have some application. I think that most engineers are beginning to appreciate the fact that, for example, the techniques of building a bridge or laying out a highway are not enough. You have to go beyond that. You have to figure what will be the effect upon the city of Washington, for example, if you are going to put in an arterial highway. Thus engineering itself has broadened. We wrestle with these problems on the Engineering and Scientific Manpower Commissions. The Scientific Manpower Commission is, of course, under NSF. I think it is an important point to distinguish that there is a tendency toward a merger in thinking.

Mr. MILLER. Will the gentleman yield?

Mr. DAVIS. Certainly.

Mr. MILLER. I, too, have wrestled with this problem, and I always find it applied to engineering, engineering scientists, and scientists. Are there any other disciplines of learning where this takes place? In the medical profession do you distinguish between the practitioners in medicine and the people who do research? Don't you have to accept more or less that any man who can do one can do the other, and if he is going to be good must do some of the other?

Dr. BATES. I think the existence of a social science area is in itself a recognition that we must bring science and humanities together in the broad scale.

Mr. MILLER. Do you think that the scientific community through the Academy of Sciences and the Academy of Engineering perhaps should undertake to make some redefinitions to bring these terms into modern connotations, because there is always this confusion I believe

that comes up when we get into this field? Shouldn't someone start to lay down some guidelines? We recognize the very gray areas that exist and will always exist. But couldn't we begin to perhaps lessen them so that we could have some guidelines in these fields?

Dr. BATES. I think in essence that is part of what I am suggesting here. I am not too worried about the definitions, as such. They are extremely useful and important. However, I believe in these areas things——

Mr. MILLER. If I may interrupt you, Doctor, they are very important. If the members of this committee can't reconcile these things, the Members of Congress who have not had the privilege of being exposed to people such as yourself would probably get quite confused. When you come to ask for money, we sometimes can't answer the questions.

Dr. BATES. Yes, I agree 100 percent with you. I think I would revise the way I started that statement to say that it is important o recognize that the definitions of today may not be the applicable definitions of tomorrow because of changes that take place. However, I would support your statement that we need, as of today, to have good definitions.

Mr. MILLER. I started life as a civil engineer and worked at it in the West before World War I, but civil engineering in those days was almost synonymous with surveying. I remember when the California Highway Commission was established in 1911. Up to that time, we built roads empirically. All of a sudden we began to find out that in certain types of soil they didn't hold up. When the department established a division to research this and to standardize materials, some people thought this was going far afield. If you wanted to build a road, you got a four-horse scraper, went out, and put a top on it. I don't know that we have exhausted all the research as to the highways. We are still learning a lot about it.

Dr. BATES. This is very pertinent and it bears on your point. I was quite interested in a column appearing this morning in the Washington Post; maybe you noticed it, on underground roads becoming a feasible answer to city needs. I brought it in because it provides an example that relates to one area of concern with which we are dealing here: the need for much more rapid tunneling to expedite all kinds of underground construction for subways, utilities, Department of Defense installations, and so on. This sounds pretty unrelated to the need for basic research until you appreciate (and this is where definition and distinctions between science and engineering come in) that you can't do the ultimate in terms of putting a tunnel through as fast as possible without knowing more than we do now of the science of rock mechanics. This involves detailed knowledge of such things as the composition and texture of the rock, how it withstands certain pressures at certain temperatures, and so on.

Mr. MILLER. The Comstock lode in Nevada was worked out because there was too much hot water in it, and they didn't have pumps. Then a man by the name of Sutro decided to run a tunnel under the mountain and drain the hot water off. He made a deal with the landowners to get 20 percent of the profits. It used to swell closed, and they would have to go into there and open it again. He did his job and he got a lot of money. It benefited San Francisco a great deal.

Dr. BATES. This relates to one of my points, basic research versus applied research, to get back to the question of Mr. Davis. The area of rock mechanics, involving detailed knowledge of strain and stress on rocks, is pertinent at one extreme to our knowledge of the continents, crustal movements, earthquake prediction, and volcanic action, and at the other extreme to such practical questions as to how well the roof of a coal mine is going to hold. Here we have an example of a situation where there is no doubt about the NSF assuming the responsibility in supporting research on the earth's crust, and there is no doubt about the Bureau of Mines assuming the responsibility of working on the problem of the room in the mine. In between, there are many gaps where neither group can now assume responsibility.

Mr. DAVIS. Then you have engineering scientists and scientific engineers, both.

Mr. FEISS. I think a very great difficulty here is the line between chemistry and chemical engineering today. With reference to the manpower commission work, it was interesting to observe that the chemical engineers were represented on the scientific manpower commission as well as on the engineering manpower commission largely because it was recognized that to be a chemical engineer you had to be a chemist first.

Mr. MILLER. Where do you draw the line between chemistry and biology?

Mr. DAVIS. I notice you set forth the R. & D. dollar figures for fiscal year 1964. Through our work on the NASA budget each year, I know this space figure. If you took the second word away, "development," you would have a small figure left. I forget what the exact figure is.

Dr. BATES. I can give it to you. I have them here.

Mr. DAVIS. Would you insert those in the record?

Dr. BATES. I will be glad to.

(The information referred to is as follows:)

Obligations for research and development for the functions shown in figure 1 of my statement are as follows in billions of dollars:

	Research		Development
	Total	Basic	
Agriculture	0.17	0.06	0.008
Atomic Energy	.33	.26	.86
Defense	1.20	.20	6.42
Health and medical	.84	.28	.003
Natural resources	.24	.13	.03
Space	2.78	.68	1.89

Source: "Federal Funds for Research and Development," vol. XII, 1962-64, pp. 128 and 129.

Mr. DAVIS. In the Interior Department, I recognize that the development of saline water conversion would require a good bit of money. Are there other areas where you spend much money on development or does most of your money go toward research?

How would Interior's budget divide as between research and development? I do not ask for the specific figure, but I just wonder if your research would be only a small fraction of the total.

Dr. BATES. No, it is the other way around. I will be glad to get those figures for you. I didn't bring them with me.

(The information referred to is as follows:)

In fiscal year 1965 our estimate of obligations for development in the Department's total research and development effort was $21.2 million. This is slightly over 17 percent of the total of about $128 million for research and development.

Mr. DAVIS. That is all I have, Mr. Chairman.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. I just wanted to explore a more or less philosophical point with you. I recognize the validity of the opinion that you are making about science management, the need to insure that we have an adequate coverage of all the fields. We have brought this point up once or twice before.

Today we are getting a primary emphasis on certain areas which became important as a result of their relationship to defense and the military. Obviously with the development of nuclear weapons during World War II we had a very great interest in basic physics, mathematics, and chemistry. The AEC is sort of a spin-off of a military development, and similarly NASA program is a spin-off. There is much concern with other aspects of basic science, but there is a great deal of overlap between physics and mathematics that concern AEC and the space program. So we have seen a great deal of emphasis on a relatively small part of the total science spectrum stemming from this relationship. What we are seeing today and what you are pointing out is the need to broaden our concepts. If we could show that the earth sciences and so forth had a direct relationship to national defense that was more important than nuclear weapons is, I am sure we would see a great infusion of money into the earth sciences. The goal of the NSF obviously was to make certain efforts to change this management picture, but the emphasis still is on these original areas of basic science. The goal of these hearings has been to investigate whether we are now ready to move on to a broader approach, and I think your contribution has been very valuable from that standpoint. You have described some areas which you title "Environmental" on page 15 which include mining engineering, metallurgy, and so forth. But this does not exhaust what might be described as environmental sciences?

Dr. BATES. By no means.

Mr. BROWN. You have listed those which are of particular concern to your department?

Dr. BATES. Yes, I did not mean that environmental and applied were the same here. The statement may be somewhat misleading. Seven of the ten subjects listed in parentheses there are largely related to the minerals sciences as distinct, although not separate from, enviromental sciences such as ecology. In this latter connection I was very interested in Dr. Ripley's statements before the committee last week with regard to preservation of cultures. As an illustration, I have a colleague who is now working on National Science Foundation sponsored research in the Everglades. He is a paleo-botanist who has been doing very fine research on the present and past effect of the salt versus fresh water environment on the cyprus, palmettos, saw grass, and other plant life of the area. It is partially through his work and the work of others in that area that we are beginning to understand the very

drastic effect that the canals are having on the Everglades. If this type of work had been done 10 years before we got into the situation where we needed these canals for the benefit of the human population, then appropriate plans could have been made to assure that engineering for human needs did not cause drastic damage to the natural environment.

In the same vein there are many places where the Bureau of Reclamation is building dams. We are making every effort to show proper concern for the environment: what is the effect of a given dam on the animal, the plant life of the region, and so on. However, we are not confident that we are doing nearly enough research with regard to natural animal and plant populations and the effect of man on the environment.

Mr. BROWN. You use the term regional planning and conservation here.

Dr. BATES. They are certainly part of environmental science.

Mr. BROWN. Really, even here you are talking about regional resource planning, using resource as a fairly broad term. You refer, for example, to the economic planning which would involve the location of businesses and the economic interaction of the community with other communities.

Dr. BATES. I am not referring specifically to that except to point out that when you talk about regional planning this is one of the best examples of interdisciplinary activity involving the physical sciences, the social sciences, and engineering; because if you are worrying about the economics of the region you must know what the mineral resources are in addition to how the population is going to use them.

Mr. BROWN. If Interior were to try to integrate all regional planning, you would probably find a lot of objections from the Commerce Department and various other agencies?

Dr. BATES. Oh, yes.

Mr. BROWN. Do you feel that the Department of the Interior has had, in a budgetary sense, all of the funds that it would usefully be able to use in this area?

Dr. BATES. There is only one answer to the question. "No."

Mr. BROWN. You haven't exhausted all the frontiers of knowledge then?

Dr. BATES. We are working hard at it but we haven't gotten there yet.

Mr. BROWN. I have a feeling that a part of the pressure on NSF to support some of these things comes sometimes from the fact that NSF has been more successful in getting funds for these things than the mission-oriented agencies feel this is a way they can get funds. I am not at all sure that perhaps the answer is not an expansion, assuming we can make a suitable differential of the research funds for the mission-oriented agencies together with a greater emphasis on this coordination and integration between agencies that you have indicated.

Dr. BATES. Yes.

Mr. DAVIS. I was going to point out that there is a factor maybe of glamour involved as well as a factor of competition with the Communist world which may enter into the fact that other agencies have been so abundantly blessed with funds. I have seen witnesses come before our full Committee on Science and Astronautics, where committee members

would ask, Could you use some more money in the space program, and the witness would answer, "No."

Mr. BROWN. I can give you some specific examples of this, if you will allow me. I made a specific inquiry to the AEC with regard to whether or not they could use additional funds for fusion research which is attempting to use hydrogen fusion as a source of power. I was told that they couldn't, that the money they were spending was all that they could use considering the state of the knowledge and the number of scientists trained in this particular field.

Dr. BATES. I would like to point out to the committee that points along the line that I am making will be coming to the attention of Congress with much greater frequency because we are moving from the era where we could skim the cream of our mineral resources into an era where, for a variety of reasons, we must do a great deal more research in order to get the same payoff relative to what is available in the ground. A specific reason (and there are a number that might be pointed out) is that as the developing countries grow in stature they will have the ability and the need to use the mineral resources that they are now exporting to the United States and other countries. The United States in 1962, according to this report,[1] was the major producer of only 8 of the 16 major metals or their ores. We are becoming increasingly dependent on foreign sources for many mineral commodities. Another pertinent fact is that in about 1900 we could only mine copper ore that had a very high grade of about 6 percent contained metal whereas now we must use grades of only 0.8 percent. This means continuing improvement in technology. I am sure you are all familiar with this. The point I want to make is that we are moving into an increasingly difficult period from the standpoint of getting the most out of the crust of the earth. This is essentially saying we must have more research, basic research.

Mr. BROWN. I think it is going to be increasingly important that in our competition with the Communist bloc we must get across the idea that competition in the pursuit of excellence must not be confined to a very narrow sphere, as it has primarily been in terms of the expenditure of basic research funds, but should be across the board. Otherwise, we are going to lose in some areas that may not seem very important to us now, but 15 years from now are going to be all important. If you can work out some tie-in in this type of competition, it might make it easier to get some budgetary allotments. I have no further questions, Mr. Chairman.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Dr. Bates. I would like to ask if it is fair to say, in the area of earth sciences and understanding our natural resources, that considerably more money is expended by the private sector of our economy relative to the Government effort than there might be in some other areas of the physical sciences.

Dr. BATES. That is correct.

Mr. CONABLE. Is there quite a bit of basic research conducted by industry, let's say the petroleum industry, for example, relative to such scientific fields as seismology, and if this doesn't have some effect of mitigating the need in this area relative, say, to the space area, where there is no immediate hope of profit or utility?

[1] NAS–NRC Publication 1000–C: Mineral Resources.

Dr. BATES. This is certainly a factor. This is the reason I pointed out with regard to this first figure that in the natural resource area the industries themselves are contributing an additional six-tenths of a billion on R. & D. The problem comes with regard to the basic versus the applied research. Certainly in the petroleum industry you can point to certain of the companies that are doing terrific jobs with regard to basic research, but the funds expended are small relative to the amount of many that the total petroleum industry is putting into the applied problem of getting oil out of the ground right now, rather than worrying about what we are going to get out 20 years from now.

Mr. CONABLE. The Interior Department must deal with lots of companies in the course of a year with respect to lumber or timber contracts, for instance. Do you impose any conditions on them with respect to research, or are the conditions limited entirely to simply the wise utilization of natural resources? How far do you go?

Dr. BATES. I will have to ask if one of these gentlemen can speak to that. I have not been with the Department long enough to give you the answer.

Mr. ECKLES. I could speak in a general way, but I do not have specific information on the subject. The situation very likely is that through the leasing allowance—for instance, through Bureau of Land Management on public lands—that they would be allowed to harvest the resources there without a requirement to do any specific task as far as research is concerned. They would be required, of course, to follow prescribed conservation practices.

Mr. MILLER. But the lumber resources come more under agriculture, don't they?

Mr. ECKLES. That is correct.

Mr. MILLER. Most of the big lumbering companies today—some of those who were the biggest violators in the past—have come to realize that they have to replace their timber. Timber is a crop, and some companies plant two trees for every one they take out.

Mr. CONABLE. I simply wondered whether the Government, the Interior Department specifically, tried to stimulate research quite beyond what you might have direct control of through your public policy with respect to exploitation of natural resources. I imagine it would be something that would be difficult to do.

Mr. ECKLES. This is rather diffuse. One of the ways this is done is to encourage industry to carry out research on their own, which has a direct bearing on the program that the Department is carrying out. It is a dialog or exchange of information between the technical staffs in the Department and their acquaintances within industry. The areas of mutual advantage are often explored, and this does bring industry along to do its own research.

Mr. DADDARIO. Mr. Chairman.

Mr. MILLER. On table 1, under the Office of Water Resources Research, I notice you spend no money in-house, but through universities you spend about $4 million a year. One of the men that helped to compile that book you were just quoting from minutes ago, I happened to sit next to him the other day, and we were talking about the future of the country in regard to water pollution. I talked about some of the problems that we were having in California, and that this stuff would be pumped eventually to the sea. He said: "You are going at it backward; why don't you reuse it?"

Is anything being done on the reclamation of sewage water for domestic and other use?

Dr. BATES. There is a great deal being done, both at the university level and as related to the Department of the Interior. The Department, through the Bureau of Reclamation, has had a contract with the University of Arizona for just this purpose for the past 2 years. Speaking from my own university experience we have a project doing just that in Pennsylvania. The effluent from the sewage plant contains detergents—nitrogen and phosphorous—which make the vegetation grow so well in our local fishing creek which receives the discharge that the fish are endangered by low oxygen content. Now we are taking part of this water out to the farmlands of the university where a truly interdisciplinary team of agronomists, foresters, hydrologists, and engineers are all working on the problem of putting the reclaimed water to good use.

Mr. MILLER. I think we are rather squeamish about this. People have to realize that sooner or later this water is going to be put back into the main.

Mr. CONABLE. This was one of the major theses of "Les Misérables" in Victor Hugo's discussion of the sewers of Paris.

Dr. BATES. In this case the top 10 to 20 inches of soil takes these chemicals out of the water and it returns to the water table in just as pure form as prior to initial usage.

Mr. MILLER. I notice in this same table about $18 million is spent on commercial fisheries and $7 million on sports fisheries and wildlife, That, of course, is more than matched by State funds, so the efforts in this field are much greater than indicated here; though, again, this is a cooperative effort with the Fish and Wildlife Service in each instance.

Mr. DADDARIO. Any further questions?

I want to thank you, Dr. Bates, and your colleagues for a very interesting morning. You have added a great deal to these hearings. We would like to have the opportunity to send some additional questions to you.[1]

Dr. BATES. I would like to thank the committee and say I have been tremendously impressed, at my first opportunity to appear before a congressional committee, with the concern of the committee, the way they have done their homework, and their real efforts here to move in a very important direction of major concern to the Nation.

Mr. DADDARIO. We are impressed, too, Dr. Bates, with the fact that people such as yourself come to Government after long experience in the academic field with such a wide breadth of knowledge and with concern about the problems of the Nation.

This is helpful to us beyond measure, and we appreciate it.

This committee will adjourn until tomorrow morning at the same place at 10 o'clock.

(Whereupon, at 11:20 a.m., the subcommittee was adjourned to reconvene at 10 a.m., Thursday, July 29, 1965.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

THURSDAY, JULY 29, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Our first witness is Dr. Arnold Grobman, who is Director of the Biological Sciences Curriculum Study. We are pleased to have you, Dr. Grobman. I understand that Dr. Mayer is with you. It has been called to my attention that you have supplied us with a table full of books and other information which will be helpful to the committee. I would appreciate it if you would go right ahead with your statement.

STATEMENT OF DR. ARNOLD B. GROBMAN, DIRECTOR, BIOLOGICAL SCIENCES CURRICULUM STUDY

Dr. GROBMAN. Thank you. I have a prepared statement, Mr. Daddario, and I would like to read it and perhaps interpolate and omit some material as I go through it.

To examine the role of the National Science Foundation in developing and encouraging scientific education in this country and in promoting the advancement of scientific knowledge in general, it is useful to look at the state of science education before the Foundation came on the scene. My concern has been with curriculum improvement at the secondary school level so I will confine my remarks to that area, and specifically, to the development of materials for the biology curriculum.

How, then, has the content of the curriculum been established in America and has the National Science Foundation had an impact in improving the content? Has the NSF contributed to the goal of improving the scientific education of our citizens and the advancement of science generally? And how, from the point of view of science curriculum improvement, can the activities of the Foundation in this area be strengthened? It will be emphasized in this report that the NSF has made a singularly significant contribution to the improvement of science education through support of curriculum study groups but that much remains to be done. It will be emphasized in this report that the NSF has made a singularly sig-

nificant contribution to the improvement of science education through support of curriculum study groups but that much remains to be done.

Let us look back, then, on how content had been determined in our schools before the advent of the curriculum studies.

It is traditional to emphasize that in America control of education is at the local level with varying degrees of coordination through State departments of education. Close inspection of one aspect of education—high school science courses—leads to some instructive insights on how course content is, in fact, actually determined.

The local school board employs the science teachers and approves the selection of textbooks. But the board does not train the teachers nor does it write the textbooks. Although the local school board has considerable legal responsibility, the de facto determination of the actual content of science courses resides elsewhere.

The State departments of education establish criteria for the certification of teachers and could, in theory, determine the kinds of training teachers receive. In practice, however, the State departments legislate in terms of course credit hours and it is in the universities where determination of the actual content of teacher instruction is made. Some State departments of education do exercise modest control over the content of textbooks by prescribing to publishers. In almost half of the States, the education department periodically stipulates one or more textbooks which schools may purchase with State funds and thus it could influence the curriculum to the extent that there are real content differences of a substantial nature among competing science textbooks. But study of available textbooks—from the period before the curriculum studies—does not reveal substantial differences among textbooks insofar as basic content is concerned. On balance, since the training of the teachers is the responsibility of the colleges, and the writing of the textbooks is in the hands of authors and publishers, the control and influence on course content in the sciences by State departments of education appears to be relatively minor.

In theory, a high school science teacher has considerable freedom to determine the content of the courses he teaches. In practice, he teaches five, six, or seven classes a day for 5 days a week; grades the papers and reports of his students; arranges for his own laboratory materials and equipment; and is often obligated for certain extracurricular activities such as lunch room duty and monitoring study halls. Unlike his collegiate colleague, the typical high school teacher has an assigned workload so overwhelming that, regardless of his honest intentions, he must depend very heavily upon textbooks for determining the content of his courses.

Suffice it to say that the argument here is that the major control of content in science courses is through the textbook. So let's take a look at the textbook itself, and I begin by talking about publishers' roles.

In the initial plan for a new science textbook, the publisher and his authors design a book that is as educationally sound, up to date, and effective as they can make it. I have tremendous confidence in the integrity, competence, and ability of most American textbook publishers to produce educationally sound and stimulating books.

When such books are placed on the market, however, there develops an effective influence on, and actual control of, content for which no name seems to be available. I use here the phrase "content determination by the nonacademic marketplace" as a label to aid in examining this phenomenon.

The initially sound books placed on the market by the publisher bring him a variety of responses. One of the first is a series of negative reactions toward certain topics by small nonrepresentative groups in different parts of the Nation.

For example, the publisher of a good modern secondary school biology book is reminded, in one State, that his book would be quite acceptable if the topic of evolution were omitted because State law prohibits the teaching of evolution in the public schools. The publisher knows that the industry is highly competitive and that if he includes evolution in his book he will lose sales to competing publishers whose evolution-free books would be adopted instead of his.

In another part of the Nation, the same publisher is told that his biology book would be welcome except that the material on human reproduction "is a little too frank for our conservative community" and so he again faces the same kind of problem and usually arrives at the same nonacademic solution. In other communities, additional controversial topics meet resistance and on most occasions the publisher reacts by modifying or omitting sections of his book in order to try to satisfy most of the special interest groups. He continues to make downward adjustments in content in order to drive his sales record upward.

Relentlessly and predictably, in this fashion, a series of debilitating deletions is made by the publisher in his biology book. Resolutely this process continues despite the clear preference—subsequently demonstrated by the wholesale adoption of Biological Sciences Curriculum Study books—of the vast—and silent—majority of both informed lay citizens and educators for a sound scientific treatment of evolution, human reproduction, and other related biological topics, in a good high school biology textbook.

It should be underscored that the question I am trying to illuminate is not whether evolution or human reproduction or any other specific topic should be taught in high school biology classes. The question is whether such determinations of what is to be taught should properly result from the pressures of small, nonacademic, special interest groups. The end result of the process I have described is substandard educational materials for the Nation.

Returning now to the publisher, his initially excellent plans for a fine book, when molded by the actual and anticipated negative pressure of the nonacademic marketplace, frequently emerge as a lifeless compendium of factual statements without controversy, without vitality, and without interest. The various publishers' textbooks become safe, sterile, and similar and not in the interest of superior education. They are bland and colorless and the students who use them are largely unchallenged, uninterested, and unaffected.

Most informed people would agree that the scholars in a discipline, and the teachers of that discipline, should cooperatively have a major voice in recommending the appropriate content to be studied in our schools. Biologists and biology teachers should recommend

the model materials to be taught in biology classes; chemists and chemistry teachers, materials to be taught in chemistry classes; and mathematicians and mathematics teachers, materials to be taught in mathematics classes. In essence, this is the great contribution of the recent curriculum study groups, such as the Biological Sciences Curriculum Study (BSCS), the School Mathematics Study Group (SMSG), the Physical Science Study Committee (PSSC), and others.

They have brought together the teachers and scholars in their respective fields and those scholars and teachers have prepared model high school courses with content appropriate for our present day and age. In making the majority of these materials available to the schools with the full cooperation of textbook publishers, the curriculum study groups have been acting completely within the traditional framework of local control of education, our free enterprise system, and the fundamental tenets of our American democracy. And they have been able to overcome much of the negativeness of the nonacademic marketplace because NSF support has made it possible for the curriculum study groups to produce their materials independently of such pressures.

Mr. DADDARIO. Will you tie together that last statement, with the one on the previous page which says that the result of the nonacademic marketplace activity brings these books to the point where they are bland and colorless? Is this still the situation, or was this the situation before the NSF support allowed some advance in this area? Where are we at this stage of the game? Up to the point you made in the last statement I thought we were going completely by the least common denominator, but apparently there has been a thrust forward.

Dr. GROBMAN. The NSF support of the curriculum study groups has permitted us to write books that scientists and science teachers think are good and the publishers have published these unchanged because our contracts with the publishers state that they may not make any changes in these books. We feel that these represent very good educational materials and the schools adopt them very gladly.

Mr. CONABLE. How are you able to get the publishers to accept this?

Dr. GROBMAN. The way we have proceeded is fairly simple. We have announced to publishers that we have a manuscript available; we invite them all to bid on the manuscript; and one of the clauses in our contractual arrangement is that they may not make any changes. Of the existing textbook publishing houses, 20 houses have bid to produce our texts and we have selected 3.

Mr. DADDARIO. Do you find that because you have this contract with the publishers, that they will accept these books as written?

Dr. GROBMAN. Yes, they are being accepted. As I plan to mention later, the BSCS books are being very widely adopted.

Mr. CONABLE. But you are doing this with only 3 of the 20, and the pressures from the nonacademic marketplace must be the same as before. Is it simply the prestige of the National Science Foundation and your group that has been able to bring this about?

Dr. GROBMAN. Not the prestige of the NSF; I hope that is not the reason. The actual content of the books, I believe, is the chief factor. Teachers' committees look at them and study them and find that these are good books and they want to use them.

Mr. DADDARIO. Perhaps you are finding out, too, that these pressure groups were not as formidable as thought to be.

Dr. GROBMAN. Yes, the publishers would react to each small voice and bring the book down to that level. When we write our books as we think they should be written, these voices still arise occasionally but, nevertheless, the books are bought and used in the schools. Publishers have been unduly conservative, is another way of saying this.

Mr. CONABLE. Perhaps we should get the National Science Foundation interested in politics to discourage some of the pressure groups that work on us.

Mr. BROWN. Would you care to comment on how this phenomenon applies to other related fields? For example, it seems to me we might have a spectrum here in which pressure might be relatively less at one end, say, with mathematics or physics—maybe I am not picking good examples—relatively greater in biology and other areas, and perhaps the extreme is those areas dealing with the social sciences or even history. Is this, in fact, true?

In other words, does this phenomenon of the nonacademic marketplace affect all teaching at the high school level or some more than the others? You are giving us examples in the biological field.

Dr. GROBMAN. You have used words that I have often used in discussing this with colleagues. I think that the trend you describe is real. Nobody gets mad at a molecule. But some persons do become concerned with evolution and reproduction. They become even more concerned with political science, history, and humanities. I think, in biology, we are in a science that has moderate social implications in this sense, and it is a good experimental place for curriculum work of this sort.

Thus for many years conditions have been ripe for the design of science curriculums by scientists and science teachers. Probably most of the innovators did not analyze the educational scene in the terms of the sketch above; they simply began with the blunt and direct observation that our physics, chemistry, biology, and mathematics courses were demonstrably substandard and that we had ample resources to do far better.

The first of the modern curriculum studies in the sciences arose because of the clear insight, serious concern, and directed energy of Dr. Jerrold Zacharias of MIT. He was influential in obtaining support in 1956 from the National Science Foundation to establish, and later to bring to successful conclusion, the work of the Physical Science Study Committee which produced a modern course in physics—the first of a series of new senior high school science courses. Chemistry, biology, and earth science programs followed.

The program in biology—Biological Sciences Curriculum Study—began in 1959 under the sponsorship of the American Institute of Biological Sciences with financial support of the NSF. BSCS

policy is determined by a large steering committee whose members, on a rotating basis, represent university research biologists, high school biology teachers, school administrators, medical and agricultural educators, psychologists, educationists, and others.

The BSCS produced three alternative versions—some of our material is on the table, which I will be glad to leave with the committee for review at its convenience—of high school biology courses known as the blue, green, and yellow versions which provide teachers an opportunity to select a modern biology course most suitable to their local needs. Experimental editions of the versions were written during the summer of 1960 by a balanced team of 70 university and high school biologists. These experimental editions were tested by 100 teachers during the 1960–61 school year and, based on that experience, the books were completely rewritten during the summer of 1961. The second experimental edition of the three versions was then tested by 1,000 teachers and 150,000 students in 47 States during a 2-year period. This extensive testing led to the preparation of commercial editions by three different publishers and the books became generally available to the schools in September 1963.

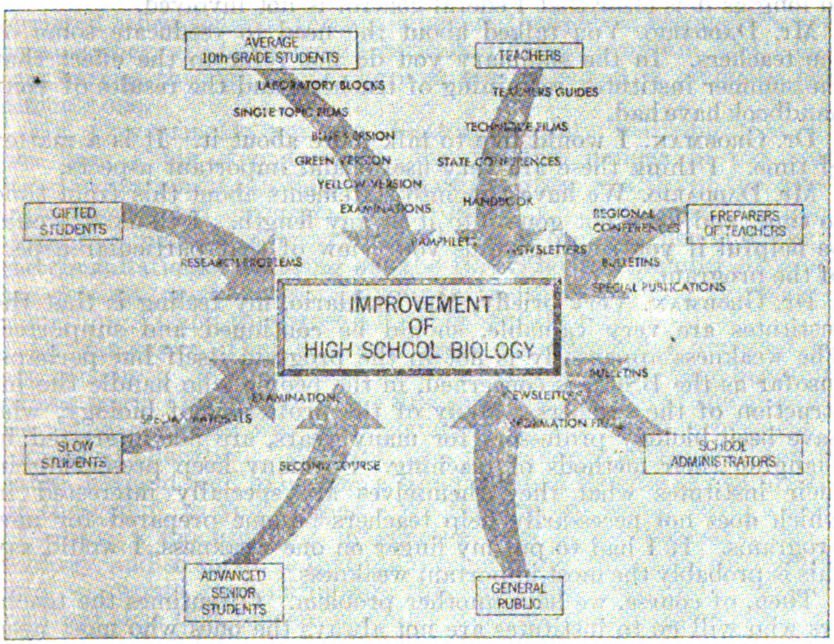
The commercially published books are extremely successful and are being widely adopted. About 700,000 students, of the 2,300,000 who were enrolled in 10th grade biology courses during the 1964–65 school year, studied from BSCS books. If present trends continue, the number should double in 2 years with a probability that BSCS books will be adopted by three-quarters of American high schools by 1968.

Of course, making these three versions of a biology textbook available for students to use was not sufficient. It was also necessary to assist teachers in their use of these new and different materials. So the BSCS prepared teachers' guides for each of the versions. Some biology teachers were found to be deficient in modern chemistry, physics, and mathematics and so the BSCS wrote a teachers' handbook covering these topics and many other aspects related to the improvement of biology teaching. Because of gaps in their early training, many teachers did not understand the use of certain modern laboratory techniques and, to attack this problem, the BSCS produced a series of films for teachers devoted to specific common laboratory methods. The BSCS also arranged a series of annual area clinics so that teachers using BSCS materials could review their procedures and problems with more experienced persons. As often as it was able to respond, the BSCS, in addition, assisted those responsible for summer institutes and school system workshops.

In a like manner, using normal commercial channels including eight different publishers, many supply companies, several film distributors, and others, the BSCS prepared supplementary laboratory blocks on selected topics to increase the flexibility of each course; a special course for slow learning students; research problems for gifted students; an advanced level course for high school seniors; supplementary single topic films to cover experiments impractical for the school laboratory; appropriate examinations for each of the courses; a series of booklets for those responsible for the training of biology teachers; lists of supplies and equipment for manufacturers

and suppliers; monographs on the history of biology teaching, working with gifted students in biology, and the design and administration of biology classrooms for school administrators; pamphlets on selected topics for teachers and students; and an information film and a series of newsletters for persons with both general and specific interest in the improvement of secondary school biological education. In addition, the BSCS has held regional conferences with educators and biologists responsible for the training of biology teachers; has conducted special orientation sessions for teachers in its experimental programs; and has arranged a very large number of conferences and committee meetings on specific topics contributing to the broad goals of the BSCS.

The BSCS is a multifaceted, total and continuing program. Its efforts are directed toward the improvement of biological education at the secondary school level which it does through the production of a wide variety of materials and through cooperation with virtually every group involved in the biological education of American secondary school students. (See accompanying diagram.)



The work of the BSCS has been financed by NSF grants totaling about $8 million through a 7-year period. During the same period, over $1 million has been earned through sales of experimental editions and through royalties on commercial editions. These moneys have been returned to the NSF for deposit with the U.S. Treasury. About 2,000 persons, other than students, have been involved in the development of BSCS materials. I am talking here about our domestic program and not our international program which I think should be another story.

Some summary statements about the BSCS could be made as follows:

1. It is the most intensive effort ever directed toward the improvement of a single course for American schools and has been highly successful.

2. It has used a scientific procedure; i.e., extensive school trials with rewritings, in the development of curriculums.

3. It has demonstrated that American high school students are capable of far more intellectual achievement than they are normally given credit for. I think this is a very important point.

4. It has shown that the majority of educational leaders at the local level prefer to offer their students modern substantive courses on which to chew rather than warmed-over pablum.

5. It has shown that American high school students, regardless of their individual career goals, have a real interest in understanding the processes of science—but not necessarily in the factual minutiae.

6. It has shown that those responsible for education at the local levels are glad to look to responsible national groups for guidance so long as it is clear that Federal control is not involved.

Mr. Daddario. You talked about the need to reeducate some of the teachers. In the summary you do not refer to the effect that the summer institutes, retraining of teachers, and the results of your handbook have had.

Dr. Grobman. I would like to talk more about it. It is a matter of time. I think these are very useful and important aspects.

Mr. Daddario. We have run into statements about this from time to time, and have not gone into it in any length. I think it would be helpful if you could give us your view of that particular aspect of the program.

Dr. Grobman. Very briefly, Mr. Daddario, my feeling is that the institutes are very valuable, should be continued and supported. The weakness apparently is not in the program itself but perhaps, insofar as the BSCS is concerned, in the people who handle the instruction of the teachers. Many of the professors of biology, who have been biology professors for many years, are not interested in changing their methods of teaching. So many keep presenting in their institutes what they themselves are specially interested in which does not necessarily help teachers become prepared for new programs. If I had to put my finger on one weakness, I would say this is probably the most important weakness.

Then, of course, we have another problem. Oftentimes the teachers who will go to institutes are not always the ones who most need the upgrading and training. Many willing teachers are unable to get to the institutes.

Mr. Daddario. You are appealing to the ones who are already pretty good and who want to improve themselves further?

Dr. Grobman. Often.

Mr. Daddario. I think the results have been indicative of great progress in this area. The type of teachers we can attract to teaching at that level is an important consideration for us to look into.

Dr. Grobman. Yes, I would think so.

Mr. Daddario. We have had occasion to talk to some of the people in the universities. They have often suggested that this is where a

great deal needs to be done. It is believed that with the right kind of programing, the right salary level and the building up of departments in the elementary and secondary school levels, that we could attract people with the desire to develop a teaching career.

Dr. GROBMAN. I think salaries are very important.

Mr. BROWN. Can I inquire at this point what effect this improvement in high school teaching is going to have? In other words, has this resulted in any shift upward in the quality of college teaching and in the quality of the biology teachers of the next generation?

Of course, it may be too early to observe this, but it is to be hoped that this would be so. I just wonder if you have any data on this.

Dr. GROBMAN. We have, yes, some information. We know that a number of schools, for instance at Berkeley, the students are now examined whether they have had a BSCS course or a traditional course. If they have had a BSCS course and do well on a little examination, they can move on to a sophomore course without taking freshman biology. A number of the colleges are doing this but not enough, I am afraid.

I believe the problems that you are talking about will in part be obviated when some of these youngsters themselves become teachers, because they will have had an entirely different program, and I hope this carries through. But the changeover period is going to be a difficult one.

Mr. CONABLE. Do you see, Doctor, possibly realizing that this has been a big step forward, any possible danger in too much standardization in this field? One of the great wealths of the American educational program is its diversity. You must be going through a process of arriving at the least common denominator in the consultations that bring out the BSCS book, a number of people are getting together and resolving their differences and agreeing on something. Can't this process itself be stultifying?

Dr. GROBMAN. That is a very good question and I am glad you are raising it. We have been aware of this from the very beginning of our work. In fact, when we first got together, one of the questions we asked ourselves was what could we do for the improvement of biological education. We said, let's not write a single textbook because it would tend to become a standard item because of the prestige of the group, as you suggest. We thought we would write a series of units, a modern unit in genetics, one in biochemistry, one in ecology, and so forth, so that the teacher could design his own courses and we would thus encourage this desirable flexibility. We soon realized that that scheme wouldn't work because most teachers, you know, teach six or seven classes a day, 5 days a week; monitor a study hall; have lunchroom duty; and so most of them simply can't design their own courses from resource materials. So we finally decided to produce several different kinds of biology books, and that accounts for the three versions I mentioned. In addition to each one of these three versions being quite different from each other in approach, each is quite flexible in that each contains twice as many laboratory exercises as could possibly be completed in the course of a year, so the teacher can pick and choose what he would like to teach. Then, as supplements, we produced the laboratory blocks with which the teacher can enrich his course. Thus we end up with

a very large number of offerings with these basic materials. We have been very much aware of the question you raised and furthermore we encourage—I do any time I get a chance—teachers to use any materials they want, not just BSCS materials, so we are not trying to "sell" one single kind of course.

Mr. DADDARIO. You are trying to establish a higher level to begin with, and give them the building blocks to go from there at whatever speed they feel they are capable.

Dr. GROBMAN. That is right. I have used slightly different words: we are trying to prepare model materials and we hope others will build on our materials or use them as examples. If we arrive at the stage where materials produced by others are superior to ours, we would be delighted to get out of business. That hasn't happened yet.

The National Science Foundation contribution to the welfare of American education, through support of the curriculum studies and institutes for teachers, cannot be overestimated. American education, with its record of rich potentialities which have been largely unfulfilled for generations, has been stimulated by NSF support into a course content improvement activity of tremendous value. From this stimulation, course improvement promises to continue and is already expanding into fields outside of the sciences. It is heartening to note that other specialists are beginning to prepare materials designed to be competitive with those of the curriculum study groups.

The NSF leadership has had the wisdom and the courage to support the development of curriculum studies when they were in their early formative stages—when they were simply ideas in the minds of a few forward-looking planners. The curriculum studies could never have developed to present productive stages without the sympathetic support provided by the NSF.

The NSF has used its good offices to arrange for scholars and leaders in various disciplines to become acquainted with each other's work thus contributing to the general effectiveness of all participants.

The NSF fiscal officers and their supervisors, while properly giving first concern to a conservative and effective use of public moneys, have been unusually helpful to the academic people involved in the curriculum projects who, often, do not have firsthand familiarity with governmental agency procedures.

Valuable suggestions for improvement of study programs have come from NSF personnel who have been responsible for the review of early proposals by curriculum study groups.

The NSF has shown good judgment in the support it has given to the curriculum study groups. American students and teachers will profit for generations to come. There is no question that the national welfare has benefited very greatly through NSF sponsorship of the curriculum improvement movement.

Now, I go into a few details about the BSCS relationship with NSF.

During recent years, negotiations between the Biological Sciences Curriculum Study and the National Science Foundation have become increasingly difficult. Perhaps the major reason for this is that the Biological Sciences Curriculum Study is pioneering in its curriculum work and is at the growing edge of many new programs.

For example, it is the first of the curriculum groups to be concerned with a thorough and complete revision of its textbooks. It is one of the few groups that sees the need to extend its developmental work. The Biological Sciences Curriculum Study steering committee has made firm plans to continue to contribute to the improvement of biological education whereas some of the other curriculum groups are satisfied to consider their work completed when they have produced a set of new course materials for their fields. These goals of the Biological Sciences Curriculum Study create complex problems for the National Science Foundation since policy guidelines do not now exist for the handling of many unanticipated questions that constantly arise.

The difficulties that have developed can, perhaps, be subsumed under a few headings. Further details are included in an attached appendix which is a memorandum I have recently submitted to the Biological Sciences Curriculum Study steering committee.

(1) Lengthy periods of National Science Foundation indecision have adversely affected the Biological Sciences Curriculum Study program.

(2) The National Science Foundation has awarded grants for short—and variable—periods which have mitigated against well-organized planning on the part of the Biological Sciences Curriculum Study.

(3) In recent years, the National Science Foundation has consistently awarded grants at the last possible moment, which procedure has adversely affected the orderly administration of the Biological Sciences Curriculum Study.

(4) National Science Foundation officials have improperly interfered with the internal operations of the Biological Sciences Curriculum Study and, upon occasion, have been needlessly restrictive.

(5) The National Science Foundation has acted adversely on grant proposals of the Biological Sciences Curriculum Study, upon the recommendation of external reviewers, without providing opportunities for discussions, either directly or indirectly, between the reviewers and the Biological Sciences Curriculum Study.

(6) The policymaking body for the National Science Foundation has not taken full advantage of the considerable experiences of National Science Foundation grantees.

(7) The National Science Foundation exercises undue policy control through its fiscal control.

In summary, I should like to make the following remarks.

The National Science Foundation support of curriculum study groups has greatly enhanced science education in this Nation. Such sponsorship of the Biological Sciences Curriculum Study, for example, has already brought about an unprecedented revolution in biological education. As a result, high school students are developing understandings and proficiencies in biology beyond all prior reasonable expectations.

In many ways, National Science Foundation has exercised good judgment. The tremendous benefit to America of National Science Foundation contributions to science education, through support of the curriculum study groups, is incalcuable.

But the National Science Foundation does not now seem to be adequately responsive to further developments, particularly by groups pioneering new activities. In Biological Sciences Curriculum Study experience, National Science Foundation appears to be slow to act, indecisive, late in awarding grants, and unfortunately unaware of the role it must play in the continuation of curriculum improvement.

The tremendous momentum that has been achieved in the improvement of science education through National Science Foundation stimulation is destined to falter unless the Foundation can begin to meet the challenges before it far more effectively.

(Appendix to Dr. Grobman's prepared statement follows:)

MEMORANDUM No. 217

BIOLOGICAL SCIENCES CURRICULUM STUDY,
UNIVERSITY OF COLORADO,
Boulder, Colo., June 14, 1965.

To: Biological Sciences Curriculum Study steering committee: Glass, chairman, Andrews, d'Arc, Arnon, Auffenberg, Boyce, Brain, Cheadle, Hurd, Jordan, Kennedy, Kolb, Larsen, Lee, Magoun, Mayer, Moore, Palmer, Rollins, Welch, Went, Williamson, and Wolfson.
New members, October 1, 1965: Liebherr, Moog, Olsen, Phillips, Read, Rohrbaugh, and Rosen.
Biological Sciences Curriculum Study committee chairmen and writing team supervisors: Hastings, Peterson, Schwab, and Snider.
AIBS: Kennedy, Olive, and Thimann.
CUEBS: Greulach and Hall.
UC: Smiley and Wilson.
NSF: Dees, Haworth, Hemily, Kelson, Mays, Paulson, Riecken, Roe, Whitmer, and Wilson.

From: Arnold B. Grobman, director.

Attached is a copy of a memorandum I sent to the Biological Sciences Curriculum Study executive committee on June 11.

BIOLOGICAL SCIENCES CURRICULUM STUDY,
UNIVERSITY OF COLORADO,
Boulder, Colo., June 11, 1965.

Memorandum to: Biological Sciences Curriculum Study executive committee: Glass (chairman), Mayer, Moore, Palmer, and Rollins.

From: Arnold Grobman.

Please consider this memorandum notice of my resignation as director of the Biological Sciences Curriculum Study to take effect on September 1, 1965.

I have accepted the position of dean of the College of Arts and Sciences of the Men's College at Rutgers University.

The opportunities for me at Rutgers are of no special interest to the welfare of the Biological Sciences Curriculum Study, but the reasons why I would be willing to leave the directorship of the Biological Sciences Curriculum Study, at a time when the study is enjoying such remarkable success, should be a matter of concern to the Biological Sciences Curriculum Study executive committee.

The remainder of this memorandum, therefore, will be devoted to those factors which have made the directorship of the Biological Sciences Curriculum Study increasingly untenable for me, I realize that some of these points may have implications for the national welfare, beyond the Biological Sciences Curriculum Study program, but my sole concern here is exclusively with the Biological Sciences Curriculum Study. I hope to contribute to an amelioration of some of the problems I perceive by bringing them to your attention through this document.

BACKGROUND

The Biological Sciences Curriculum Study has developed into an entirely new kind of organization for which there seems to be no name available. Some day, Biological Sciences Curriculum Study-type organizations will take their place, along with schools, colleges, State education departments, textbook publishing houses, and boards of education, as necessary partners in the American education movement. Essentially the Biological Sciences Curriculum Study has become a service contributing in a total way to the improvement of biological education at the secondary school level. For 10th-grade students (the level at which biology is normally taught), the Biological Sciences Curriculum Study has produced three alternate basic courses with tremendous flexibility provided through laboratory blocks, single topic films, and supplementary exercises. For gifted students, it has produced four volumes of research problems and for low-ability students a special course is now nearing completion. A program titled "The Interaction of Experiments and Ideas," was recently published for students selecting a second course in biology (usually at the 12th grade). A complete testing program has been designed for all of these students and consideration is being given to the development of a new college entrance examination in biology. For teachers of biology there are now available, through Biological Sciences Curriculum Study efforts, recommendations on equipment and supplies, guides to the versions, a teacher's handbook, films on laboratory techniques, a series of subject matter pamphlets, and an annual series of State-by-State conferences. For those responsible for the training of teachers, both within the school systems and on the college campuses, the Biological Sciences Curriculum Study has produced a series of special publications; has participated in many institute training programs; and is planning a series of films on teacher preparation for Biological Sciences Curriculum Study biology. For administrators and others concerned with the environment in which secondary school biology should be taught, the Biological Sciences Curriculum Study has published three bulletins dealing with the developmental history of secondary school biology as well as with the design and structure of high school biology laboratories. For all these persons, as well as for others with an interest in biological education, the Biological Sciences Curriculum Study has prepared an informational film about the Biological Sciences Curriculum Study as well as a continuing series of periodic newsletters. Through these various avenues, as well as through nonacademic agencies (textbook publishers, equipment manufacturers, and film distributors), the Biological Sciences Curriculum Study is having a multiple-pronged impact on the improvement of biological education at the secondary school level. This is a virtually unique breakthrough in the improvement of education in America and deserves the fullest encouragement possible until its full impact can be adequately assessed.

There have been a multiplicity of collateral benefits accruing from the activities of the Biological Sciences Curriculum Study. Perhaps the simplest way to indicate some of these would be by referring to the real and meaningful communication channels that have been widened between university and college biologists and biology teachers, science supervisors, principals, superintendents, professors of education, testing specialists, science educators, curriculum specialists, equipment designers, textbook editors, and many others.

The impact of the materials can be indicated by pointing out that the basic versions are currently being taught to about 700,000 students and every time four schools adopt a new biology book, three of them select a Biological Sciences Curriculum Study version.

Nor are the effects of the work of the Biological Sciences Curriculum Study limited to the United States, Specific adaptations of the basic courses to the local fauna, flora, and educational systems (not merely translations) are currently being prepared by teams of biological colleagues in Argentina, Australia, Brazil, Canada (French), Colombia, Israel, Italy, Japan, New Zealand, Philippines, Taiwan, and Thailand. Special instructional sessions have been held, in addition, in Ceylon, Denmark, England, Guatemala, India, Mexico, Peru, Turkey, and Venezuela.

PROBLEM OF BUDGET PERIODS

Through the short (six and a half years) history of the BSCS, we have had to work, at one time or another, with 4-month, 5-month, 6-month, 8-month, 12-month and 15-month budget periods, each at the direction of the National Science Foundation which provides our major financial support. Rational planning based on comparable fiscal studies is virtually precluded. The shorter budget periods make for almost impossible administration.

PROBLEM OF TIMING OF GRANTS

Our proposals to the National Science Foundation for support of the BSCS have normally been submitted about 4 months before they were due to take effect but grants have not been awarded on schedule. For example, our proposal for support for the calendar fiscal year 1965 was submitted to the NSF in August 1964. Pursuant to this proposal a grant for a 4-month period was made by the NSF on December 28, 1964, 3 days before the start of the new fiscal year. A revised proposal was required for the remaining 8-month period starting May 1, 1965. A letter extending the grant period to December 31, 1965, was received from the NSF on May 11, 1965, 10 days after the fiscal period had started and grant funds were awarded for only 2 months. Presumably further funds will be made available about July 1 for the last 6 months of 1965. Virtually all grants to BSCS, in response to proposals, have followed patterns similar to that outlined above. Of eight major NSF grants, under which the BSCS has been financed, seven were awarded less than 1 month prior to the scheduled due date and, of these seven, three were actually awarded after the due date. It is virtually impossible to operate an on going program under such conditions.

PROBLEM OF INTERFERENCE IN INTERNAL OPERATIONS

It is, of course, axiomatic that the NSF must be kept fully informed about the expenditures of funds made available through its grants. Honest differences among men of good intent will certainly arise in defining the boundary between proper control of grant funds by the NSF and unwarranted interference in the internal affairs of the grantee by the Foundation. I believe that the Foundation has erred frequently on the side of interfering in matters that are internal BSCS responsibility. For brevity, I will simply identify a few examples here without full discussion.

In 1962, after the AIBS mismanagement came to light and without consulting the BSCS, the NSF transferred management of the BSCS to the University of Colorado. Whether this was the best of several solutions possible at the time is irrelevant to the matter of the unilateral action taken by NSF.

Shortly afterward, without discussing any of the details with BSCS, the NSF, AIBS and the university entered into a tripartite agreement under which assignments of the copyrights of books written by BSCS authors were made without including the BSCS.

It was the considered opinion of the BSCS (with which opinion the publishers agreed) that the revision of the versions should begin in the summer of 1965 for publication in 1967. Unilaterally, and despite a special appeal from the BSCS, the NSF decided that this was too early and, as a result, would not support revisions for this summer.

The United States-Japan Committee on Scientific Cooperation, Panel on Education in the Sciences, in 1964 approved a joint program to be held in Tokyo in 1965 devoted to a revision and adaptation to Japanese conditions of the BSCS blue version biology textbook and laboratory manual and to a study of the Japanese Science Education Centers for the renewal of training of secondary school science teachers with a view to their applicability to American education. In spite of the fact that much of the planning for the joint writing conference in Tokyo was initiated by the BSCS, and involved BSCS personnel and policies, the BSCS was excluded from any direct participation in the operation of the joint study other than to nominate two persons to represent the U.S. participation.

PROBLEM OF PERSONNEL

Frequent remarks by NSF staff members on the question of "phasing out" of the BSCS now "that its work is done" have had demoralizing effects on the BSCS staff. Many members of the staff are hesitant to commit themselves for more than a year's service and at least one man has resigned to accept a post with a publishing house at a most substantial reduction in salary. His primary reason for leaving was to avoid uncertainty in continuity of employment; he wanted to be in one place long enough for his children to complete high school without moving.

Other remarks by NSF staff, to the effect that "the BSCS is being run by the same small handfull of people," has caused the BSCS executive committee to adopt a very stringent rotation policy. Rotation of policymaking personnel and professional staff members is desirable, within limits, because new ideas are thus brought to the BSCS (and, conversely, the BSCS developments are introduced to wider audiences) and the staff and committees enjoy continuing intellectual stimulation. Except for the chairman, there has been 100-percent turnover of steering committee members since rotation was initiated in 1961. More significant, and quite distressing, is the disruption caused within the professional staff through this policy. Of the eight full-time academic persons currently on the staff only one will remain a member of the staff after September 1. Nor is this an exceptional year.

The tremendous burden placed on the director in continually recruiting able and specialized personnel, and annually orienting new staff members to their complex responsibilities, need simply be mentioned to be appreciated. In addition, the lack of continuity in staff member contracts with persons outside the study has thrown more and more of this kind of responsibility on the director. I am convinced that the BSCS suffers very seriously because of the lack of staff continuity resulting, in large part, from NSF indecision and thinking out loud. At the very least, the BSCS is adversely affected because the time of the director is usurped so that he is unable to use opportunities to perform at higher levels.

PROBLEM OF MANAGEMENT

The transfer by NSF of fiscal management of BSCS from AIBS to the University of Colorado in November 1962 was regarded by all concerned as a temporary measure. To assist in reaching a solution to this difficult problem, the BSCS has made two positive recommendations for NSF's consideration: Management by an existing private educational institution or management through a corporation whose members would be a group of colleges and universities. The feasibility of these two approaches has been fully explored by the BSCS. The BSCS also invited the AIBS executive committee, which wishes to resume management of BSCS, to describe its plans to the members of the BSCS steering committee. In October 1964 after a full meeting and discussion between the two groups, the BSCS steering committee met separately and voted unanimously against the resumption of management of BSCS by AIBS at this time. To these three recommendations, the NSF's reply is that it is studying the matter. Two recent letters to NSF officials on these management matters remain unanswered. In the meanwhile, two and a half years have passed and we seem to be no closer to a solution of the BSCS management problem than we were in late 1962.

PROBLEM OF PROPOSAL REVIEWS

The method of appraisal of BSCS proposals seems completely inadequate. The proposals, which are complex and have involved more than $1 million annually, are reviewed by referees and NSF staff. Reviewers appear to be largely unfamiliar with the activities of the BSCS but there seems to be little hesitation, on the part of the NSF, to delete budget items (e.g., revision writing conferences for the summer of 1965) on the recommendation of such reviewers. The director of the BSCS has never had an opportunity to discuss the BSCS program with a panel of reviewers nor to demonstrate BSCS facilities through a site visit by a panel of reviewers.

SUMMARY

The situations alluded to above, and the implications that follow directly from them, as well as many other aspects of our present operations over which I have no adequate control, have combined to make the position of director of the BSCS increasingly untenable for me. I hope that my resignation will stimulate corrective measures.

THE FUTURE

The long range promise of service by BSCS to biological education is obvious to all who are familiar with the study. We need to continue our current programs and extend our international activities; we should plan for a very substantial revision of our versions so that they will continue to be both challenging and modern and will not simply become a new orthodoxy; and we must prepare to participate in extension of our efforts into the junior high school.

Rather than discussing such long-range plans, I will simply refer here to some items of immediate importance for the executive committee.

With the exception of the directorship, and two responsibilities discussed below, the staff for next year has been recruited and is of high quality; it promises to be one of the best staffs the BSCS has ever had. I have not been able to find a person to assume the responsibilities for the evaluation program and, as a substitution, I am exploring the possibility of contracting with an outside responsible agency for this service. I have not yet hired a person for public information services but I do not think that this will be a serious problem.

The 1965 budget is approved and funds are at hand for operations through June 1965, with additional funds for the last half of 1965 anticipated shortly after July 1, 1965.

Only preliminary work has been started on the proposal for 1966; I believe the proposed budget should remain fluid until the new director is appointed.

Please be assured that I will be happy to contribute, in any way I can, to a smooth transition of the directorship. I stand ready to devote my full efforts to this end prior to September 1, 1965, and all the time I can possibly spare after that date.

Each of you knows me well enough to appreciate how reluctant I am to send this memorandum to you. We have shared, with ourselves and with many others, the fine successes the BSCS has enjoyed and we have shared, alone and without rancor, the failures as well. These six and a half years have been tremendously exciting and rewarding and I shall ever be in debt to the members of the executive committee for the encouragement they have given me.

Mr. DADDARIO. Dr. Grobman, have you, in the appendix to your statement, covered some of these points in broader detail?

Dr. GROBMAN. That is right.

Mr. DADDARIO. I think it might be helpful if you could go into some of this from the standpoint of pinpointing it more precisely. We recognize the problems of continuity of budget support.

What do you believe the situation is at the moment? What more can be accomplished? What needs to be done? How can the NSF play a better role? What are the lines of communication between you? What do you see as the means which are available to help?

You have a pioneer program, here. Mr. Brown has alluded to possibilities in many other areas, where similar programs would be of assistance. I think your observations would be of immense value to this committee.

Dr. GROBMAN. That is a difficult question.

The problems arise, as we move in new areas—let's take one example; maybe it will help to have a concrete example. The books we have written were published in 1963, and we felt it was time to have the books revised this summer. Now, by revising them this

summer, that means they would be available in 1967, because it takes that long to get the manuscripts prepared and printed, especially when we work primarily in the summers as we bring people in during vacation periods. So in our proposal to NSF, which we wrote in August of 1964 to include work for the summer of 1965, we included a request for funds to prepare the revisions. I understood that the proposal was submitted to external reviewers and they said, "Well, the books were written in 1963 and here they want to revise them in 1965; that is much too soon," so NSF declined to grant funds to us.

Well, we have had a long correspondence, and I have brought samples along to leave, if you like, about this question of revision. The correspondence now indicates that the NSF didn't understand why we wanted to revise the books.

Well, I can hardly believe that is the case. If the external reviewers said to the NSF, "It is too early," I would have been glad to have someone from BSCS talk with the NSF and the reviewers to try to demonstrate that it isn't too early. It is a normal cycle, in publishing, to revise books on a 3-, 4-, or 5-year cycle. We were aiming at an average cycle. But there was just a loss of communication, and the loss of communication was, in my eyes, due to the fact that the BSCS wasn't permitted to become involved in the considerations of its proposal.

I get the feeling sometimes that we are being treated as a property, rather than as people. And I also have the feeling that sometimes the NSF scientists and academic people, with whom we work, will concur with us on our problems and proposed solutions but then, somewhere along the line, they are overruled by either their legal or fiscal people and roadblocks are thrown in the path of the progress we would like to make.

I don't know what the solution is to this problem. I fully understand that there must be fiscal and legal control, naturally. The solution must lie within the NSF including the problem of effective communication with the grantee.

Another example concerns the copyrights on our books. The arrangements for the copyrights are among the NSF, the American Institute of Biological Sciences and the University of Colorado. But the BSCS is not permitted by this triumvirate to have a role to play in the copyrights and, after all, the BSCS is actually the collection of people who wrote the books; they should obviously be involved in the copyrights.

Maybe another way of saying this, Mr. Daddario, is that there are two main components to the production of these textbooks. One is an intellectual component, which the BSCS has contributed, and the other is the fiscal component, which NSF has contributed. Both should be represented in the control and the administration of these materials, and not just the fiscal interests alone.

Mr. DADDARIO. You see conflicts in here of an unresolved nature, obviously?

Dr. GROBMAN. Yes. So far. I have no recommendations as to how to solve this, but it is a very serious matter to us, of course.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I have no immediate question. I would like to come back a bit later.

Mr. BROWN. I am quite interested in the problems which you have cited here. I particularly am interested in whether or not this is an indication that there may be alternative ways of handling this overall educational job of curriculum improvement, other than what we have been doing.

Specifically, I would like to inquire as to the rationale why a broad program of curriculum improvement for the high schools of this country necessarily is best supported by the National Science Foundation rather than, say, the Office of Education, which is presumably responsible for the Federal Government's role in education on a much broader basis. Furthermore, is there any reason why the efforts at curriculum improvement need to be limited to biology, or the sciences, or any other one area? Are, in fact, efforts being made in other areas to parallel the efforts made in biology? And, if so, where do we draw the line between what will be done under NSF sponsorship and what will be done under Office of Education sponsorship?

Dr. GROBMAN. I think part of this is historical, Mr. Brown. When the NSF began functioning, you will remember, it first started supporting research workers, and then helping teachers with summer institutes, and then the curriculum studies. In those earlier days the Office of Education was not nearly as large and vigorous an organization as it is getting to be now. It does now support curriculum projects, and I believe there is a mechanism between the NSF and the Office of Education to see which projects are more appropriate for each agency. There are many curriculum projects going on in English and history and in social studies, oftentimes supported by Carnegie or Ford Foundation or some other private source. But the best work has been done in the sciences, in part because of the point you raised earlier. You remember, we talked about the fact that the physical sciences have less emotional connotations? For this reason, science is a good place to pioneer in curriculum improvement. I think we can get at the basic problems, without certain kinds of emotions being raised, by investigating science curriculum improvement first, and this may give us clues as to how to proceed in other areas.

I would like to see the NSF encouraged to continue in this area and, using this experience, to have more curriculum work done in other fields, perhaps under some other agency.

Mr. BROWN. The basic mandate of NSF is to strengthen basic research in science. The tool of curriculum development is merely a tool toward the ultimate strengthening our our basic scientific research resources in this country. It seems to me that we are growing closer and closer to the situation where NSF is undertaking general support of education when it gets to the point of modification and improvement of curriculum. This expands from one area of science to many areas of science, and to areas on the fringes of science. I wonder—and I do not think we will resolve it here this morning—whether we need to take a broad look at this in terms of strengthening our whole basic structure of education at the elementary and secondary level. Do it as a means of improving the quality of our society and not

purely in terms of an adjunct to the strengthening of basic research in the physical sciences, which is the way it is developing at the present time.

Dr. GROBMAN. I would like to make two remarks in response, if I might.

First, to strengthen basic science, we really need to have better science courses in the schools, because otherwise we lose the interest of youngsters in science even before they enter college. So this could be considered—what is the term you use here—a mission goal: curriculum improvement in science. But then I agree with your further point, which I think would be a very useful thing for this country to engage in, to support curriculum studies of this nature across the board. This should not be under NSF, and it should be under some other more representative body.

Mr. DADDARIO. Will the gentleman yield?

Mr. BROWN. Certainly.

Mr. DADDARIO. There is some curriculum study going on in the Office of Education. The point is raised that it ought not to be in just one agency because there ought to be some competitive aspects and diversity to this.

I think Mr. Brown's point is an extremely important one from the standpoint of what this committee finally recommends. It would be helpful if you could go into Mr. Brown's question in a little depth. What are these competitive aspects, and the importance of diversification?

Dr. GROBMAN. I am not too sure I understand the question.

Mr. DADDARIO. Should NSF be in it, at all?

Dr. GROBMAN. Oh, yes.

Mr. DADDARIO. I think this goes to the heart of Mr. Brown's question.

Dr. GROBMAN. I think NSF should not only be in it, but be in it more strongly until there is some other way of handling this broad problem.

Mr. DADDARIO. You have been involved with this for some time. What other ways are available?

Where do we go from there? I think this program of yours is running into difficulties because of the points which Mr. Brown has raised.

Dr. GROBMAN. It is running into difficulties, you can say it that way. You can say it is so because the NSF is not being flexible enough, which, I suppose, relates to the problem. I don't know the answer. I think what you are asking for is a long-range solution. I have brought to your attention what is a relatively short-range problem. The long-range solution certainly should involve the total support of curriculum studies by the Government in some other agency than NSF, but I don't see what the agency would be, right now. The Office of Education has not yet had a history that would give one confidence in its supporting this well; maybe it could have such a direction in the future.

Right now I wouldn't personally be enthusiastic about such a home for general support. I agree, further, that it should not be left to the private foundations, alone, because they can come in and

withdraw as they will, and this could be contrary to the national welfare.

I am not too worried about the question of diversity if the supporting agency has multiple supporting funds so it can sponsor several curriculum groups or one large one that has good representation from many people in the field. I have oft-times thought that one way to handle this might be to have a presidential adviser on education, outside of the Cabinet. But this would not be a way of financing curriculum studies, but rather making educational information available to the local schools and local school boards.

I suppose on balance, the best home for support of curriculum studies would be the Office of Education, but I am not now enthusiastic about it.

Mr. DADDARIO. You feel because NSF has made the start that it should perhaps continue and expand at this time. When the Office of Education has reached the point where it can take it over, we should reexamine NSF's role?

Dr. GROBMAN. I would go just a touch further than that, Mr. Daddario. I would say that the NSF should not only continue but should be encouraged to proceed further because it is supporting models for curriculum design and improvement. It happens to be doing so in the sciences. I think we have got a lot to learn from what the NSF is doing, and the curriculum projects it supports, as to how we might want to move in the future with broader projects.

Mr. BROWN. How broad is the NSF support in the sciences? What progress has been made in fields other than biology, just very briefly?

Dr. GROBMAN. Very early there was a program in mathematics, supported by Carnegie, and the NSF has subsequently been supporting that study. Large NSF support involves mathematics, physics, chemistry, anthropology, and earth sciences curriculum studies at the high school level.

Mr. BROWN. Have they resulted in this type of BSCS books?

Dr. GROBMAN. None of them as extensive, but the physics program has resulted in a book and many supporting films. There are two chemistry programs. They have all, I think, been very good programs.

Mr. BROWN. Has the model or method of support been similar to the one in biology? In other words, has NSF provided funds under a contract arrangement with a group such as the American Institute of Biological Sciences, or a similar organization which has actually done the work?

Dr. GROBMAN. Yes. It is through a grant arrangement rather than a contract arrangement, and usually to a university or a group of scholars.

Mr. BROWN. Are these arrangements as broadly based as in biology?

Dr. GROBMAN. No, I would think ours are a little broader in terms of the products, because we have tried to do many more things. Most of the others have limited their interest primarily to designing a course and the related materials, and have stopped there.

Mr. BROWN. The thing that worries me is not the specific administrative location of a program for funding a particular curriculum

development project, but whether or not there is in some location an overall responsibility to see that there are no gaps left of any significance. There should be a general upgrading of curriculum so we don't have in one school a tremedously effective biology course and a ridiculously ineffective course in history or something of that sort. If there is a responsibility of this overall nature, I don't think it makes too much difference whether NSF continues to take a segment of this and some other organization takes another segment, or private foundations take a piece of it. We will get the job done, and it may be better to have it done in a diversity of ways. But I don't see at the present time where this overall responsibility lies, and maybe we haven't recognized it yet.

Dr. GROBMAN. I agree with that, completely. The overall responsibility now rests in the hands of local school boards—they can select what they like to use—or in the State departments of education, or the teachers or the principals.

I do think that we need some kind of good answer to your question. What we are doing now in these curriculum studies is building better blocks, but no one has shown us how to build an edifice out of these blocks. We need some kind of architectural structure. It shouldn't be from the Office of Education, because this obviously would be so confused with Federal control in the minds of the people that it would be a very difficult thing. We do need some kind of recommendations as to which are the best arrays, the best because of experience and teaching, the best arrays of courses to use in a particular kinds of situations. Yes, I think you are right.

Mr. BROWN. Is there any particular reason, other than historical, as to why the support for this program in biology comes from NSF rather than NIH?

Dr. GROBMAN. The NSF was in the curriculum improvement support business, and when we got started, I guess it was the only source we knew about. I don't know of any NIH support of curriculum study at the high school level. There may be, but I don't know of any.

Mr. BROWN. No further questions.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. Is the concern about possible control in HEW a concern of yours, or a concern about the possibility of misinterpretations of control of curriculum improvement?

Dr. GROBMAN. Do you mean broadly, or just for our program?

Mr. CONABLE. You mentioned that too much curriculum control from HEW might be interpreted as Federal control with all its undesirable implications.

Dr. GROBMAN. I am not worried about that, because I think the Office of Education and the NSF are capable of divorcing themselves from this and letting the content be strictly in the hands of the writers, but it would be awfully difficult for school people to understand this. It would just be a very difficult thing to explain, and they wouldn't see the situation clearly.

Mr. CONABLE. Maybe this is a matter of curiosity more than anything else. You have said roughly a third of the biology courses in the country now being taught are using your materials. Can you

generalize about the geographical distribution of the acceptance of your program?

Dr. GROBMAN. Well, it is nationwide. There isn't any real—well, there are a few weak areas. It is a bit slower in the South, and in part that is because many of the Southern States have a State textbook adoption program in which a State commission will adopt books for the whole State, and they will do this only once every 5 years, and many of these 5-year adoptions haven't come up as yet.

It is a little slower in New England. I suppose that is perhaps because of some conservatism there, and it is a little slow in New York. I am sure this is because of the regents exams and the people in Albany who have decided that they want students to prepare for the regents, but the regents haven't followed these programs, as yet.

Mr. CONABLE. But you don't draw any unhappy conclusions from these weak spots? It is just a matter of time, probably?

Dr. GROBMAN. Well, of course, these people would say they are not weak spots.

Mr. CONABLE. I understand, but from your point of view, they are?

Dr. GROBMAN. Yes.

Mr. CONABLE. But you are confident. I believe you have said that three-quarters of the schools in the country will be using the BSCS materials?

Dr. GROBMAN. By 1968, if the present rate of adoption continues.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I notice with interest on page 11 of your remarks that you quote an estimated dollar figure of about $8 million with roughly $1 million return. I would gather the $1 million return will probably increase through sales and royalties?

Dr. GROBMAN. Yes.

Mr. VIVIAN. Over a period of time, this may all be returned?

Dr. GROBMAN. I don't think so.

Mr. VIVIAN. Or some larger fraction?

Dr. GROBMAN. Certainly a larger fraction.

Mr. VIVIAN. Supposing I were to estimate the total amount of money spent on the preparation of textbooks in comparable work over the last few years within the commercial enterprise; would it be comparable?

Dr. GROBMAN. It would be negligible, compared to these figures.

Mr. VIVIAN. In other words, it is not so much a question of shifting the financing of textbook preparation from an established pattern of commercial enterprise through their typical fees to authors and royalties and so on, but of increasing the scope and level of textbook effort by a significant amount in the field?

Dr. GROBMAN. I would say that, but there is also one other point, which I think is a key factor. When publishers prepare textbooks, they are scarcely written by high school authors. They are called in-house preparations. They are written inside the publisher's office by his editors. There are authors, of course, but they don't contribute the substantial amount when they do, and the publisher says, "Look, Joe, this won't sell, we know from our market experience"—the publisher greatly influences the product that comes out. This is unfortunate for American education. I think, rather than the

quantity of work, that the real contribution of the curriculum studies, at least in biology, is that they have been able to produce books representing the thinking of the scientists and the science educators rather than the thinking of what the publisher feels he can sell.

Mr. VIVIAN. How does the publisher introduce new material?

Dr. GROBMAN. You mean before the advent of the studies?

Mr. VIVIAN. Yes.

Dr. GROBMAN. The publisher's books are quite up to date. The latest things are in them, and they are carefully studied so that everything is accurate, and there is nothing factually wrong but the books are dull little encyclopedias and the kids aren't interested in them. The publisher has reviewers, but he also is controlled by this other factor (non academic marketplace control) I have been trying to describe, perhaps before you walked in.

Mr. VIVIAN. Let me switch to a different, but related, question. On page 18, you have a list of the steering committee members.

Dr. GROBMAN. The original proposal to the National Science Foundation came from the American Institute of Biological Sciences, which is a national organization of biologists, and it selected a steering committee, and these members were included in the first proposal, I believe. This is no longer the same list, because people have rotated every year, you see.

Mr. VIVIAN. Does the selection of the steering committee or the other participants represent any conflict between yourself and the National Science Foundation?

Dr. GROBMAN. None, whatsoever.

Mr. VIVIAN. In other words, there is no dispute as to who the members would be or where the power of decision lay, and what members constituted that list?

Dr. GROBMAN. No. The NSF just wanted to be sure that there were competent and capable people, and there are certainly many such among that group, and that seemed adequate for the National Science Foundation's view.

Mr. VIVIAN. Referring to the appendix, have you received back from the Foundation a vacuum or a deluge?

Dr. GROBMAN. A vacuum.

Mr. VIVIAN. How much time has passed; 1 month?

Dr. GROBMAN. This was mailed out on the 14th of June; yes, sir.

Mr. VIVIAN. If we were to ask the people of NSF, do you think we would receive a vacuum?

Dr. GROBMAN. You would receive a deluge, I would think.

Mr. VIVIAN. I notice you have said you have received a contract from NSF for your efforts, and you have indicated that textbook revision efforts in other areas had received grants.

Dr. GROBMAN. If I said that, I was mistaken. We have been supported entirely by grants.

Mr. VIVIAN. The others have been supported entirely by grants?

Dr. GROBMAN. To my knowledge, yes.

Mr. VIVIAN. Who in the other subcommittees have written similar memorandums?

Dr. GROBMAN. For the other curriculum studies?

Mr. VIVIAN. Yes.

Dr. GROBMAN. I do not receive their memorandums, so I don't know. I would doubt there is any other. I think the reason is we are trying to do different things than the other.

Mr. VIVIAN. How many other curriculum groups are there?

Dr. GROBMAN. Oh, they are actually many, some very large like ourselves and some very small; many small ones. The NSF has published a list of these, a nice booklet.

Mr. VIVIAN. Have these other curriculum studies had similar funding periods and have they experienced any similar delays in the award of grants?

Dr. GROBMAN. I know that some of them have, from personal chats with directors.

Mr. VIVIAN. I would like to make a comparative study of this, Mr. Chairman, if resources are available.

Mr. DADDARIO. Information on other curriculum study groups supported by NSF will be obtained by the staff and furnished for the record. (See appendix, vol. II.)

Mr. VIVIAN. In terms of the effort that was put in, do you feel very confident that your documents were competently done by a unique process with excellent results?

(Dr. Grobman nodded affirmatively.)

Mr. VIVIAN. I have no reason to dispute this, and the acceptance thereof is probably a pretty good criteria.

Let me ask a question: Would 5 years be an adequate period for repeating this endeavor, or do you construe it as being a continuing endeavor, or do you think a different group of people should be involved?

Dr. GROBMAN. That is a moot point, because we do have a different group of people involved continuously. Our steering committee rotates one-third every year, for example, which changes our policies, sometimes drastically, sometimes subtly. We keep rotating people through our writing teams, and we rotate people through our staff. In fact, of our professional staff this year of nine people, I think eight will be leaving. It is a tremendous rotation.

I think the program should be continuous, because to get all the momentum started and to them cut it off and rebuild again would be a tremendous waste of time and money, and it would be difficult to recruit good people to start over again on something that has already been continuing.

Furthermore, there are many things that can be done between revisions of these major books. For example, many teachers, through no fault of their own, aren't really prepared to handle some of the finer points in some of the material in these books. We can't get them all to summer institutes; we can't get them all to briefing sessions. One of the things we would like to do is to prepare a series of nine films, each one taking one of the major topics in these books showing a good master teacher presenting it to a classroom.

This is something we could do very nicely between revisions of the books. There are other projects of that nature that could help the whole program contribute further, if we were sure we could essentially be a continuing organization.

Mr. VIVIAN. Could you continue at where you are now, at half, or more; maybe double?

Dr. GROBMAN. We were up to 2 million a year. We are down to 1.2 million. I think something in the neighborhood of 800,000 would be quite adequate for us, indefinitely.

Mr. VIVIAN. How much competition is there in the republishing of these textbooks? Suppose some firm which is not publishing textbooks wants to publish some?

Dr. GROBMAN. These are copyrighted.

Mr. VIVIAN. By whom?

Dr. GROBMAN. The American Institute of Biological Sciences.

Mr. VIVIAN. What has the policy of the——

Dr. GROBMAN. Our policy is to be extremely liberal, and we are glad to let any publisher who wants to use any of our materials in his book use 10 percent without any cost. This is an extremely liberal provision, but no publisher has yet taken advantage of it.

Mr. VIVIAN. All royalties are returned to the Federal Treasury?

Dr. GROBMAN. Yes.

Mr. VIVIAN. There is no question as to who is coming out ahead in terms of profits on the publication of a book?

Dr. GROBMAN. No money, no royalties accrue to the writers. They were paid a stipend for their work. All the earnings go to the NSF which I understand deposits them with the Treasury.

Mr. VIVIAN. You indicated you had some disputes with NSF regarding funds and administrative conditions. Many scientific groups that are having difficulties with, say, agency A proceed immediately to agency B. And for good reason. Did you ever ask NIH for funds to continue the endeavor or expand any facet of it?

Dr. GROBMAN. No.

Mr. VIVIAN. Was this because of what I will call being gentlemen or because you didn't think you would succeed?

Dr. GROBMAN. I think the main reason is we just didn't have the manpower available to conduct these explorations.

Mr. VIVIAN. Did you consider going to the Office of Education for these funds?

Dr. GROBMAN. We have asked the Office of Education for one grant for a teacher preparation activity, and we haven't received it.

Mr. VIVIAN. Did you ask the Office of Naval Research for any funds?

Dr. GROBMAN. We did debate that. Our policy committee decided we should not ask mission-oriented agencies for money because we felt our goal was not mission oriented. We didn't want to be under the obligation of including a certain amount of atomic energy or a certain amount of health or something of this sort. So we have only gone to what, in our lingo, are "pure" agencies.

Mr. VIVIAN. You indicated earlier that you thought the distinction between the Office of Education and the National Science Foundation is that some people wouldn't understand. What do you mean by this phrase?

Dr. GROBMAN. We were talking in a different context, not about the development of these materials, but rather in terms of an overall recommendation of the kind of curriculum program that should be

used, and if such a recommendation were to come from the Office of Education, I am sure that many school people, school administrators for obvious or devious reasons would say, oh, there is Government control, this is not what you want to do, the Government is trying to get into things, and it would be an awfully difficult public information education job to clarify the real situation I think.

Mr. VIVIAN. Why is it different with the National Science Foundation?

Dr. GROBMAN. Because the National Science Foundation is not, from its offices, announcing what are good or poor curriculums or making any recommendations whatsoever. The Foundation is merely supporting a group like the BSCS and the BSCS can succeed or fall on its face with no public evaluations from the NSF.

Mr. VIVIAN. If we were to combine the Office of Education and the National Science Foundation and relabel it the "National Education Commission," what would be the situation? I am trying to find out whether labels or substance is involved.

Dr. GROBMAN. If the Office of Education or the National Science Foundation were to support curriculum studies, I think there would be no problems, the problems would be extremely minor. But if either one of those organizations were to recommend a series of curriculums for the schools to use, then there would be great reaction.

Mr. VIVIAN. Does the Office of Education now recommend curriculums?

Dr. GROBMAN. No; it does not.

Mr. VIVIAN. So why should it make much difference?

Dr. GROBMAN. We were talking before about the question of whether there should not be some kind of national group recommending how these various curriculums could be used together and whether there were gaps in our coverage and things of this sort. Such a recommending agency should not be part of one of the present Federal agencies.

Mr. VIVIAN. Doesn't the NEA——

Dr. GROBMAN. That is a private organization.

Mr. VIVIAN. Doesn't it have a committee which has more or less this function?

Dr. GROBMAN. If it has, it is not very effective.

Mr. VIVIAN. If there is a deficiency in this particular zone, it should be in a sense laid to the private organization itself?

Dr. GROBMAN. No; I don't think that is right either.

Mr. VIVIAN. I said if there is a deficiency. But go ahead.

Dr. GROBMAN. Oh, there is a deficiency, I don't think there is any doubt about that. I don't think it should be a private organization because a private organization cannot be representative of the consumers of these materials.

Mr. VIVIAN. Why not? If it isn't private, it has to be public. And you said it shouldn't be public.

Dr. GROBMAN. No, I didn't. I said I don't think it should be one of the existing agencies. I don't know of any existing private agency that could do it. I think one way this could be done, this is outside the realm of my competence, but I throw this out as an interested citizen, one way this could be done is through a Presiden-

tial adviser on education with a good staff of people who could look at these curriculum studies, bring together groups to review them and other things, and then report to the President and say, "Based on our experience we find that one of the better ways to teach biology at the 10th grade is to use BSCS materials, it has this advantage and this deficiency." This Presidential adviser could also say, "We have explored the teaching of foreign languages and we find that the schools that are using beginning foreign languages in the elementary grades are doing a much better job than those that begin them in the secondary grades," or the reverse. Some kind of impartial recommendations coming from such an adviser I think would be of great benefit to the school people providing they didn't carry any kind of coercion or control.

Mr. VIVIAN. Do you think it is better if it comes out of the President's Office than if it comes out of the Office of Education?

Dr. GROBMAN. I think in the present climate it would be more acceptable; yes.

Mr. DADDARIO. Dr. Grobman, we only have a few more minutes, but in the time remaining, I wonder if you could touch on the effect that this work has had in foreign countries. You refer to that in your memorandum.

Dr. GROBMAN. Briefly, almost immediately when our materials were available, a number of our colleagues in foreign countries wanted to use them and translate them. We said, no, you can't translate them because the animals and plants in Peru are different than those here, or the educational system is different. You will have to adapt our materials before you can use them. This general policy has led to the establishment of adaptation committees of educators and biologists in a large number of countries, in Thailand, Japan, Taiwan, Argentina, Brazil, Colombia, and so on. We have had very many contacts with these people. We are helping them to develop new biology books for their own countries. The Philippine book is just off the press. It is the first biology book ever designed for Philippine conditions in their history, and I think it will be a wonderful contribution to science education in the Philippines. Much of the financial support for these programs has come from agencies like the Agency for International Development, the Asia Foundation, Rockefeller Foundation, very little from the National Science Foundation. It has been a very, very exciting, and satisfactory program except that we can't get enough funds to continue it on the level it should be conducted. I think it is a very useful thing because not only is it helping these countries to develop their scientific potentialities, but it is also establishing a kind of a person-to-person relationship among scientific colleagues without going through Government agencies in most instances. It is very satisfying on both sides.

Mr. DADDARIO. It is probably a relationship that has not existed through other international cooperative functions.

Dr. GROBMAN. It is a different kind of thing, yes.

Mr. BROWN. Mr. Chairman, could I have one short question?

Mr. DADDARIO. Why, of course.

Mr. BROWN. You mentioned your seeking of funds to prepare a series of films by master teachers. The next step in a course of this sort, it would seem to me, involves perhaps making these available on television, perhaps developing automated teaching of various sorts so that the effect of these courses can be disseminated on a much broader basis with a minimum amount of master teachers involved. Has additional thought been given to this rather pioneering aspect of the matter?

Dr. GROBMAN. Mr. Brown, we have given a lot of thought to that problem. First I should say there already exists a biology course on film that the AIBS put out about the time we started. That exists already. Our own feeling is that the best way for youngsters to learn science is by working in the laboratory or in the field. So we are, as a group, rather cool toward many of the audiovisual devices that a number of people are enthusiastic about today. These devices have a place, but it is not as large a place as their proponents would wish. So we have rather developed materials designed so that students could work in the laboratory and discover these things themselves rather than make them spectators of a film.

Mr. DADDARIO. Dr. Grobman, I want to thank you for coming. It has been a very interesting morning. We are limited by time in the extent of our questioning, but I hope we might be able to send some additional questions to you for the record.[1]

I want to apologize to Dr. Brady for not having had him appear this morning, but we will try to work that out for another time.[2]

We are happy to have had you here, Dr. Grobman.

Dr. GROBMAN. Thank you for inviting me here.

Mr. DADDARIO. This committee will adjourn until Tuesday next at 10 o'clock at the same place.

(Whereupon, at 11:30 a.m., the subcommittee was adjourned to reconvene at 10 a.m., Tuesday, August 3, 1965.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

[2] Dr. Brady has submitted a prepared statement to the subcommittee which will appear in the appendix, vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

TUESDAY, AUGUST 3, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

Our witness this morning is Dr. Jerome B. Wiesner. He is the dean of science at the Massachusetts Institute of Technology and former science adviser to the President. Dr. Wiesner has been a witness before this committee on many occasions, and a man whom we hold in highest regard.

We welcome you, Dr. Wiesner. I understand you do not have a prepared text and that you will give us the benefit of your informal advice.

STATEMENT OF DR. JEROME B. WIESNER, DEAN OF SCIENCE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. WIESNER. I apologize for not having a prepared statement. Mr. Yeager asked me to participate in this hearing just before I left on a 5-week trip abroad, from which I have just returned, and I didn't want to have the pleasure of that trip spoiled by the necessity of worrying about preparing a statement. Instead, we agreed that I would be sent all the prepared statements presented to you, and when I got home I would read them and add anything which I believed had been left out.

So I have spent the weekend reading an enormous stack of testimony, which I presume you have all had the pleasure of reading and hearing elaborated. Practically anything that I can think of saying about the Science Foundation is contained in those documents, so it has been a bit hard for me to decide precisely what to do. I thought I would make some general observations based on my own observations of the NSF and then stress those matters discussed in the papers which I feel are particularly important and pertinent.

In your letter to me you also suggested that you would be interested in my observations about the general relationships of basic research in general, and of the Science Foundation's effort in particular to problems facing our Government and the problems of our Nation as a whole. I want to break the discussion into two pieces: First I would like to discuss the role of research in general in our society, and then

51-204—65—vol. 1——42

examine the role of the National Science Foundation within this particular framework.

I know that this committee on many occasions, and other committees of the Congress, too, has spent a great deal of time looking into the question of basic research and of technology in relation to our national security and economic development. As a matter of fact, this committee has stimulated discussions during the past 2 or 3 years with the result that there has been a tremendous increase in the understanding of the role of basic research to the technical development programs in this country and, as a matter of fact, I believe that as a result there has been a very great improvement in the understanding of this problem.

There has been, even among some scientists and engineers, a confusion about the complementary roles of science and technology, applied science and engineering, and the discussions of the last year or two I think have helped a great deal to clarify this in the mind of the Congress and the public as well as the practitioners.

There is no question at all that it is quite proper to regard doing basic research as an investment in the continued well-being and progress of our Nation. Scientists themselves may do research for other reasons—mostly because they like to work—but there would be no particular reason for the Nation making such very large investments in research if the only motivation was the esthetic one. At least we would then have strong arguments for making equal investments in the arts and music.

I think it is our confidence, based on past experience mostly, that the ever-increasing physical well-being of our Nation, our increasing affluence, is highly dependent on a continuous flow of knowledge about the universe. But when you try to get away from this very easily propounded generality, it gets a little harder to be specific about the facts. This is, of course, an important problem for us as a nation to face and one on which I spent a great deal of time when I worked as the President's science adviser. I know it is also one in which the committee has a continuing interest. That is, what is the proper level of research effort? What is the proper balance among the various possibilities? Who should make the decisions? How should the Government intervene? And what are the dangers of too much Government support?

These are the general social problems that we must be concerned with, and in a sense understand before we can become very specific about the role of the National Science Foundation in the total picture.

One of the most entertaining things that I did when I worked here in Washington—some of you have heard me talk about this before—was to try to get some feeling for what the proper level of research and development expenditures in this Nation should be. I believed that some of our time should be spent trying to achieve a judgment of whether what we were doing was right, whether we were spending too much money or too little, whether the Nation would be better off if we had more aggressive R. & D. efforts, and the White House group spent a fair amount of time trying to understand this question.

I talked with economists on the White House Council of Economic Advisers and others on many occasions, but I was not able to develop very specific criteria for answering these questions. I doubt if one can

really be very qualitative about these questions. It is, in a sense, a question with no answer, partially because of the nature of our society itself. Our society is not a planned system, in fact it is far from it. My own characterization of the society is that it is kind of a learning machine which learns by doing a lot of experiments, and you can't plan the experiments because the experiments are performed by a very large number of different people. Some succeed and some fail, and the Government is trying to participate in this process when it gets involved in the support of research or education or something else effecting the direction of the society. Since this is not a process that can be characterized with any high degree of precision, decisionmaking in any part of it obviously cannot be made extremely precise.

The economists were able to give me a sort of rule of thumb for research and development expenditures which would satisfy Congressman Vivian because of his engineering background or anyone else who has a mathematical background. They said that one should increase research and development expenditures until the resulting marginal increases in productivity equal the increased expenditures.

Now this is what in our business—electrical engineering—we would call an impedance matching process, and it is one which in electrical and mechanical systems is the way to get the maximum energy out of a power source, and it is also the condition which would provide maximum growth in our economy. All of this assumes, of course, that you can measure these things.

That is, of course, where the hitch comes. No one knows how to measure the contribution of a piece of basic research to economic growth. By and large, the things we do today depend on investments going back as far as over a hundred or more years, though largely during the past decade or two. In fact, this illustrates one of the most pleasant characteristics about scientific research; the information you gain is never obsolete. As you do gather more and more data, you know more and more about the world. You never need to do the same experiment over to learn the same fact.

Knowledge is investment that will last forever, and this fact makes it pretty hard to reach a judgment about the value of research as an investment. You certainly can't put a monetary price on the value of penicillin or the worth of jet-powered aircraft over piston craft. So really you can't go very far trying to be quantitative about the value of research.

However, you can get some feeling of the situation by asking how far from being at the condition mentioned earlier are we in our research investments. Here again you can get into some arguments because economists will not agree that all of the increase in productivity comes about as a result of research and development. In fact, they actually maintain that a larger share of it comes from enhanced training and education than from research and development. I would counter that the education would do no good if it were not for the more sophisticated society that technology makes possible. In any event, you can get an argument here.

I have estimated how much the marginal increases due to increased productivity amount to. If you assume that productivity is going up about 3 percent per year, you find an approximately $20 billion a year

increase in the GNP as a result of research and development. This is the total increase in productivity and is the result of all past R. & D. investments. I will arbitrarily attribute 15 percent or $3 billion of the increase to last year's increase in investments. This would indicate that one can afford very much larger increases in our R. & D. budget than the Nation has been making and still argue that it is a good investment.

In any event, I conclude that with a $2-billion-a-year basic research budget and spending in both the private and public sector approximately $20 billion a year total for both research and development, that we are nowhere near the point where increased expenditures would be a drain on our economy rather than a stimulant.

On the other hand, one can't generalize. There are obviously some expenditures which clearly will make a major contribution to economic growth and others which it is hard to be sure will have any effect.

So one shouldn't depend only on the economic justification. In fact, I want to be very careful not to give the impression that I believe that an area of basic research should be supported only if one can demonstrate that there is some likelihood of economic return, because the historical record shows that it is impossible to predict what areas of basic research are the ones that are going to turn out to have important practical consequences, and I think those people who propose—and there have been some proposals in the past, in fact, one was made to your committee last spring—that we make judgments about the way to allocate research money—basic research money—on the basis of our ability to guess about the possible importance of the outcome or the relevance of this research to related fields are making an extremely dangerous proposal. Furthermore, the intellectual value of the research must be considered.

There is a corollary, of course. If there is a field that is important to us and it requires basic research data to make something possible, as in the case of many space or military developments, we can certainly augment the supporting research effort. We often call such work applied research because we need the resulting information though the work itself might very well be characterized as fairly fundamental. But in those fields where our motives are not clear, we shouldn't try to guess ahead.

What I am saying is I think the Nation is in a position to profit from continual high-level research expenditures and, I believe, from increasing research expenditures.

We know that R. & D. expenditures increase at the rate of about 15 percent per year. This has been so, on the average, for the past decade and a half. I doubt whether we can afford to allow the total research and development expenditure to go on increasing at that rate for many years. When I worked down here in Washington, a member of the staff said one day that he could prove to me that the President had to be a scientist in 1984.

I said, "How are you going to do that?" He showed me a curve of the gross national product and the research and development expenditures, and by fudging just a little bit he got them to cross by 1984.

So it is very clear that this rate of growth in R. & D. expenditures cannot continue indefinitely. In fact, during the past year we have seen a very substantial reduction in the rate of growth in the develop-

ment programs, which I think is reasonable, particularly in the defense fields, where we now have a much better understanding of what we are doing than we did a few years ago.

In the basic research areas the Government's policy—that is, the administration's policy which I hope the Congress will support—is to see that basic research continues to grow at approximately 15 percent a year. I am not convinced that even that is enough, and I will tell you why in a few minutes.

The questions of balance between the Science Foundation and the other agencies, once you have established a national policy, also presents some difficulty. In most of the documents I submitted to you that I have seen the point is made that the Science Foundation's share of basic research support is probably too small.

I concur with this view; that is, the NSF share of the total Federal basic research effort is not great enough to allow it to be the dominant factor in policy determination that it ought to be nor can it provide adequate national leadership. But after saying this I would like to make it very clear that I do not think that other agencies should not support basic research for a variety of reasons.

I think the quality of mission-oriented activities in agencies would suffer very greatly if they were not involved in basic research—suffer because they wouldn't have as good people on their staffs, suffer because their relationships with academic and nonprofit and industrial research organizations would be poorer, so that I feel it is vital that the Defense Department, AEC, NASA, Interior, HEW, and other groups continue to be an important factor in the support of basic research, but I believe that in the future one should provide additional support in such a way that the Science Foundation does become a more important factor.

There is another point here which I know some of you have heard me make before. I am an anarchist at heart, at least I believe in insuring the possibility of multiple activities in our society. As I said earlier, I believe our form of society is one that encourages experimentation by a variety of people, and that we make our progress by trying things and recognizing errors.

I am convinced that competition is vital in basic research as well as in the economic aspects of our country. To have several agencies able to support interesting activities is an important ingredient in our society. If we don't want to end up with too much bureaucratic control and a kind of slow responding scientific support that we find many other countries suffering from and trying to get away from we should fight very hard to preserve the multiplicity of support.

I know that many people who have testified before this and other congressional groups don't agree with me and would like to see a Department of Science with strong control of all the Federal funds. Although superficially this might appear to be more efficient, I think it would be a very bad mistake.

For all these reasons, while I would support increasing the ratio of the NSF's share of the Federal budget in basic research over what it is now—I gather it is about 14 percent—some of the people who have talked before have suggested something like 25 percent, I don't know whether that is the right figure; it certainly shouldn't be 80 percent and I think 14 percent is too low. One can start to let it grow—in fact,

I gather this is happening—and watch it and see when we believe that we have reached a healthy balance.

There are a number of other points that were made in discussing the role of the Science Foundation, specific points, which I would like to pick up. These are essentially in the order in which I took them down as I made notes in reading the documents, rather than in a logical order or order of importance.

One of the most serious problems that the Foundation and the Government has faced in recent years has been the question of the geographic distribution of research support. During the past 5 or 6 years there has been a growing recognition around the country and in the Congress, and in the rest of the Government, and particularly in the Science Foundation, that the economic well-being of the various geographic areas is related to the existence of a good strong technological base, and that we have to do something to insure that such a base is available in all areas.

Those of us who had the executive responsibility for trying to do this were also concerned lest we hurt many good things that already exist. For instance, we felt that in the Defense Department it was important that the basic criterion for the allocation of Federal moneys, particularly in development but also in research supported by the Defense Department, should remain that of getting the maximum amount of national security for our expenditures. Where this is consistent with the objective of area development, one can certainly push in that direction.

We also feared the consequence of allocating the moneys of the NIH and the NSF on some geographic basis because we felt that the primary criterion should remain the promise of the proposed work.

But there have evolved a series of additional programs both in the Science Foundation and in the Office of Education aimed at trying to build up better competence; that is, to increase the number of first-rate research and teaching institutions in the country, and I believe that these relatively minor programs, minor on a national scale, have proved that these concepts are good, and it would seem to me it would be useful to push these, and push them very hard.

I would like to add an aside here. Many people have been impatient about the relatively slow rate of growth of the National Science Foundation as compared to other research and development activities in the country and when one considers, for example, that NASA was created in about 1958 and now has a $5 billion a year budget to support work in a rather relatively limited field and that the Science Foundation, created almost two decades ago, has only about 10 percent of this budget to support a vast variety of scientific fields, you can see some justification for this concern.

The National Institutes of Health budgets have also grown more rapidly. Some people claim that the Board of the Foundation has been too timid. I suspect that on occasions they have been.

Some people believe that the management of the NSF should have been more aggressive. But in the fact the extent to which Federal activities will be supported depends largely on what the executive branch, the President is willing to do, and particularly what Congress is willing to do. And because the Science Foundation, until it became deeply involved in educational research and development, had

no mission-oriented activities, it found it hard to convince the executive branch of the Government that it should grow rapidly. Furthermore, because it had no mission-oriented responsibilities, it did not receive strong congressional support, at least not like the groups that were responsible for space, atomic energy, or military developments.

One shouldn't lose sight of how important the congressional understanding and support of these activities is and has always been. The reason that we have had a very good and strong atomic energy program is easily traceable to the interest and activities of the Joint Committee on Atomic Energy. I think that the interest of the Congress in space activities, the early hearings, and the continued interest of your group, has been an important factor in the understanding and support there has been for our space program.

Until recently, at least, this kind of understanding and support for basic research and particularly for the activities of the Science Foundation has been lacking. I hope that the interest that you show now is just the beginning of a continuing involvement in basic research in this country, and particularly a fuller recognition of the important role of the Science Foundation in our scientific activities.

Just to go on with the points that I found in the documents, several people raised the problem of increasing control, redtape, and bureaucracy, not only in the NSF, but in all the agencies that are involved in support of science, and I think this is a fact. This is a result first of all of the fact that the sums of money are larger, therefore the concern about the proper use and effective use has been growing, but also because there has been a feeling on the part of some people in Congress, but I must add not in this particular group, that you can deal with research in the same way that you can deal with procurement, and you can't.

You can set up controls which attempt to find out what people are doing, which attempt to keep track of their time, and you can in fact create a very efficient accounting system, but the net result of this most likely will be merely to slow down and frustrate research activity rather than to improve it.

Certainly universities and the large corporations that support research believe that the maximum degree of flexibility and freedom in choosing programs and changing them is the way to insure the most effective use of their money. And I would suggest that it would be extremely useful for this group at some time, I won't go further into the point, to dig into this question and to see whether the trend toward growing bureaucracies in our support of science can't be reversed and still provide a situation that is consistent with the responsibilities which both the executive branch and the Congress must exercise in the use of funds.

Part of the paperwork problem has come about as a result of fiscal considerations; that is, there have been periods when the support for basic research didn't grow as rapidly as the demand for funds was growing. But during the late fifties, for example, when the basic research budgets such as the Science Foundation budget were held level, crisis was avoided by shortening the term of grants.

There was a time when grants were made for 3 years, and then they were shortened to 2 years and even 1 year. We have not recovered completely from a situation where some grants could only be made for

1 year because funds were so limited. This by itself increased the amount of paperwork since research workers had to apply for grants each year instead of once every 3 or 5 years. This involved them in more proposal writing, more negotiating with the sponsoring agencies and also produced more uncertainty on the projects. Furthermore the agencies have to deal with three times as many proposals if they make grants for 1 year rather than 3 years.

The magic number, 15 percent per year, is worth some examination.

First of all, there is sort of a natural or internal rate of growth of scientific activities, if one lets an activity run by itself without putting any restraints on it, or at least no restraints other than the requirement that what people want to do be justified on the basis of the scientific worth of the activities.

Then, I suppose, largely as a result of the rate at which one can educate new scientists and the rate at which one can build equipment and do experiments, there is sort of a natural limit that is pretty close to the 5-year doubling time which we have been living with.

Furthermore as long as activities are growing fast, most of the people doing research will be young people, and this is probably good because young people are the most creative people. But this also means that they are in the stage of their career where their salaries are increasing rapidly. I would suppose that nationwide, in industry and in universities, the salaries of the bulk of the scientists and engineers are increasing at approximately 5 percent per year.

Then there is a certain degree of inflation, which seems to be larger in the technical community than in the Nation as a whole. Certainly the cost of living has not been going up very rapidly in the last 3 or 4 years, but the cost of scientific activities do still increase. The technicians' cost seem to go up, the apparatus we use get more and more costly. As fields get developed and more and more sophisticated, the questions that are asked require more elaborate tools, and the costs go up for that reason.

All of these factors are involved in the 15 percent per year growth. There is very little we can do about this if we are prepared to accept the criterion which I proposed we do for at least the next few years; that is, to support those good basic research activities.

Mind you, I am saying basic research, I am not saying applied research or technology. There I think one has to look much more carefully at the purposes and be sure that proposed investments are worth making.

The documents reflect the pet hobbies of some of the witnesses, and I have some of my own. There are some specific areas which people feel have been neglected and which, I am certain, cannot be funded properly even if the 15 percent per year increase in basic research in the Foundation is continued.

Several people, Dr. Walker and several others, complained, and I think that is the right word for their statement, about the fact that engineering research has not been adequately supported by the Foundation.

I think that is probably true, but I think the fault lies not so much with the Foundation as with engineering community in its failure to recognize just what should be done and to come forward with adequate programs.

I believe that it is very important to try to do something about this for several reasons. First of all, I think there are a number of important national problems to which engineering research could make a major contribution and which are not as likely to be adequately handled by commercial interests or governmental activities. They might be done by Government, but I think they can be enhanced by stimulating activity in the universities, in the public sectors, which I am sure you are all familiar with, such as pollution control, more efficient medical engineering, atmospheric measuring equipment, oceanography, getting more and cheaper water-system engineering in transportation and city planning, and so forth. These are fields where large-scale research in engineering techniques could make a major contribution and in which the universities and engineering schools have had very little involvement. I think more basic research here would make a major contribution.

There is another very important reason for supporting these areas—I have only listed a few, I could list housing, urban development with proper kind of planning, maritime developments—not only would we benefit from the knowledge we gain in these fields, but I think the kind of engineering activities that have gone on in universities and in engineering schools have distorted our engineering community by creating specialized interests for the graduate students.

People tend to want to continue in the kind of research or development activity that they started in their graduate education and research activities.

Because of the problems the Nation faced during the past two decades—for a great many of us these activities were largely in the military field—engineers become particularly competent in advanced electronics, aerodynamics, radar technology, communications, and similar specialized fields. They are important, and we should go on supporting them.

On the other hand, we haven't been turning out a group of young people who are interested in and excited about some of the other very important problems, and I think we could give a tremendous stimulus to these fields and to the national economy by supporting the universities in these fields, encouraging them to do such engineering research.

So I would think that the Science Foundation should try to develop a stronger program in the engineering sciences than it has had.

You have heard much during these discussions about the educational activities of the National Science Foundation, the development of new curriculums and so on, and I think these are very good. I have been impatient about the fact that we are not doing more in these fields. I think the opportunities far exceed the accomplishments to date in the development of better educational methods and better science teaching programs. The possibilities extend far beyond the possible contributions to education in science to education in general.

I think there are contributions to be made by this kind of research and development to the whole field of education, and the work is badly needed. So I would encourage a considerable enhancement in these activities.

I think that the behavioral sciences have been inadequately funded by the Nation, not only by the Science Foundation but by all of the

agencies in the Government. This situation has been improving in recent years, the Science Foundation has been trying to do something about it and so have the National Institutes of Health, but I think that in a society which is so dependent on understanding of the relationship between the human being and the society on other human beings, we are not really spending enough money in these fields.

I would include in this group the broad field of the communication sciences, economics, the behavioral sciences, and the social sciences. The question of what is appropriate for the National Science Foundation to support and where to draw the line has never been resolved. There has been great reluctance to have the NSF support social science research, but unfortunately there doesn't seem to be any other group that can provide broad general basic support for this important area, and failing to find one or create one, I believe it is better to ask the Science Foundation to broaden its range of interest and support them strongly rather than to continue the past neglect.

A serious problem for the Nation, and particularly for the universities—and here you must recognize that I have a vested interest—is the need to use computers extensively in the educational process. The use of computers in research and the rapidly increasing use of computers in education, particularly in science and engineering education, has created a considerable crisis in American universities, of which you may already be aware though I didn't see it mentioned in the documents I received.

The use of computers in universities is growing at about twice the rate of their research and development activities, and consequently almost every substantial engineering school and school of science is at the point where it can no longer afford adequate computational facilities. Every school that I know well, including MIT, is involved in a series of maneuvers involving ad hoc arrangements to keep its computational activities solvent and to provide some time for academic use.

Without very substantial increases in tuition or other sources of funds to pay for computer time, schools will not be able to an adequate job of educating scientists and engineers to do their work in the most efficient way; that is, with computers.

I don't know precisely what should be done about this. Last year I looked into this problem and made an estimate of the need. Two things are required. Many schools need means of acquiring additional computational facilities. In this respect MIT happens to be fortunate, but there are very many other universities and engineering schools in the country that are inadequately equipped with computers.

Some means should be devised to provide them with better computational facilities. Second, there is a need to provide fiscal support for the academic on teaching uses of computers. I really don't know how this should be done. Possibly this is not a task for the National Science Foundation. Perhaps the Office of Education should have the responsibility for this, though most of the immediate opportunity in education is in the field of science and engineering.

I think this is probably the most serious single special problem in higher education—aside from the normal needs for buildings and so on—which I am sure you know all about, the most serious single problem confronting scientific and technical schools.

Many people, in their statements, make the observation that several traditional fields are undersupported or underequipped. I believe that is actually true. One can readily demonstrate this in the fields of chemistry and mathematics, and it is probably true in the new fields, the emerging fields such as the environmental sciences, but I think you have so much testimony on this subject that I needn't say any more about it.

There is another group of educational problems that I would like to see the Science Foundation do a great deal more about than it has in the past, and those are the special problems the small colleges have in the teaching of science. There are literally hundreds, maybe as many as a couple of thousand small colleges and junior colleges, schools not interested in giving professional education in science, but who should do a reasonably good job of teaching elementary and intermediate science if we are ever to have citizens with some understanding of what science is all about, something I regard as important in our modern society, and if we are going to be sure that students in these schools with an aptitude for doing creative research or engineering receive an education that both stimulates them and makes it possible for them to go on.

This is not the case today in too many of these small schools and they need a lot of help with equipment, staff, and curriculum development. We should develop special courses that can be taught well in spite of the limited facilities available in these schools. The Federal Government should consider providing special facilities to support, and even some way of supporting science faculties in these schools.

At the moment it is impossible for many of these schools to attract and hold really competent teachers. Maybe we should have a Government Science Corps in which there are people who can move in and out of these smaller institutions, who can also work in the Government laboratories, can be science attachés abroad, or work part time in the bigger universities and in industry so they can stay current.

I can't recommend the proper organizational invention here, but the problem is certainly one of our very serious ones.

Finally, a number of the previous witnesses talked about international science activities and the roles of the NSF in them. I personally believe the NSF should be encouraged to play a bigger role in the international scientific field. There is a great deal of merit in exploring more cooperative projects.

An obvious reason for cooperation is that some activities are getting so big that it is desirable to share the cost internationally.

There are many other advantages in cooperating with the mature countries, particular advantages both from the point of view of the nations themselves and from our point of view. There are also many reasons for having modest cooperative activities which don't have the stigma of aid, with some of the scientists in the developing countries, and I believe that the NSF ought to be encouraged to play a role in this field.

Mr. Chairman, I have rambled over a whole series of subjects. I probably should stop and let you pin me down on the questions that are on your mind.

Mr. Daddario. You have talked about the research going on in the various agencies, and the fact that the National Science Foundation

should play a larger, if not indeed the dominant, role. How do you bring this about, considering the attraction there is in such agencies as the Department of Defense and NASA?

Dr. WIESNER. Well, first of all, the Science Foundation itself should not become involved in directly carrying out research. I don't believe the Science Foundation should have its own laboratories such as NASA, the DOD, the AEC, and the Department of Commerce have, so it doesn't have a need for large full-time research staffs. It obviously needs some extremely able people to plan policy, to approve and monitor programs and so on, but the staff needs in the Science Foundation are much smaller than they are in the DOD.

The important thing to do here is to make it clear in terms of both policy and support that the National Science Foundation is one regarded as one of the dominant agencies in the creation of policy for basic research and in its support. The only way to do this is to support much of the research we are talking about through the National Science Foundation.

I believe that as the responsibilities of the Science Foundation grow, its stature and its power will grow. I don't think you can legislate this by just—in fact, this was tried in the original National Science Foundation legislation. The NSF was given a great number of responsibilities and powers, which its Director found he was not able to exercise from his relatively minor position in the Government scientific hierarchy. But, as in recent years, the support for the National Science Foundation has grown and so has its stature and its importance. I think that is the way we should continue to strengthen the NSF.

There are a number of important research fields that could be supported in several ways. All things being equal, we should give priority in the broad general fields of science to support through the route of the National Science Foundation, but taking care, as I said earlier, to be sure that we do not stifle or seriously damage the research components of the other agencies. I regard this as a very great hazard that we must avoid.

Mr. DADDARIO. As the National Science Foundation has grown, it has played a bigger role, and it still needs to play a bigger one, according to your statement. How is it staffed to meet this new challenge? Is it large enough? Could you relate the size of the staff to the Director and the National Science Board?

Dr. WIESNER. I certainly believe that in some areas the Science Foundation's staff should be increased, augmented. There is no question about the fact that its responsibilities have grown faster than the staff has grown to support them, and if you continue to support the Science Foundation and its activities continue to grow, it is obviously going to have increasing staff needs.

It has some unresolved problems which in part relate to people and in part relate to policy issues which are still unresolved. There is the problem of how one supports large scientific projects, for example. This seems not to be fully and satisfactorily resolved. I know that the Director is aware of this. He got his baptism in the Science Foundation trying to wrestle with the Mohole project, and he recognized that the procedures that are fine when you are dealing with modest grants, even substantial grants, are not adequate to manage multimillion-

dollar individual projects. In some of these areas that I have talked about, such as the educational research and development field, I have been critical in the past of the Science Foundation's lack of aggressiveness. I think this comes about because the staff in these areas has been overworked, and here a few more people there might lead to more activity.

I want to make it clear that I think the Science Foundation has done a good job as is reported in the various papers that discuss its activities, but I think the opportunities are so great that one ought to press them a good deal harder.

The question of the relationship between the Board and the Director is one about which there have been substantial differences of opinion. I personally believe the Director's hand should be strengthened. The situation has never been serious because the relationships between the directors and the Board I think has always been good.

On the other hand, there has been a certain amount of ambiguity. If the Board insisted on functioning with its full responsibilities or tried to review all of the grants and projects, it would find it an impossible job for a part-time board. In fact, the Board has delegated most of the detailed responsibility to the Director and his staff. We recommended, during the development of Reorganization Act No. 2, that the Board be made policy adviser and that all of the operating responsibilities be given by law directly to the Director, rather than being delegated by the Board. Several Board members objected with sufficient violence and with a sufficient number of arguments that I concluded that they might be right and I didn't pursue it. I still think this is a point that is worth considering and examining.

I think if you want to attract an outstanding scientist, such as Dr. Haworth, as Director of the Foundation, one should be prepared to give him the maximum amount of responsibility, just as we do the other operating heads of executive agencies in the Government.

On the other hand, because of the complicated relationships existing between the universities and the Government, and the fact that a certain amount of isolation from autocratic Government decisions is desirable in this particular area, the Board should be left with a great deal of power in the policy field.

My first reaction to the proposal for a full-time Chairman of the Board made by Dr. Walker, is negative.

Mr. DADDARIO. If there were to be a full-time Board, should there be a full-time staff?

Dr. WIESNER. I don't see how you can operate with a full-time chairman and a full-time staff. I think that all you would succeed in doing by this change would be to make the Director subordinate to the full-time Chairman of the Board. I think this would add an echelon of management without really accomplishing anything.

Mr. DADDARIO. Can you separate the functions?

Dr. WIESNER. I have not thought about this particular proposal in great detail. I saw it only yesterday when I read these documents, and there may be reasons for it of which I am not aware.

On the other hand, I think to argue by analogy with industrial corporations, or even MIT, as Dr. Walker does, is really a bad mistake.

Few corporations run successfully with a full-time chairman of the board and a president, unless one or the other is clearly the operating

head. At MIT the situation is unusually fortunate. The president and the chairman, as a result of a great many years of association, do work very well together. This has been particularly good for MIT. But most of us recognize that this is a fortunate accident, and it is unlikely that one could run a university this way ordinarily.

To draw any general conclusions about the feasibility of running the National Science Foundation this way from the MIT experience would be a very serious mistake.

I have less strong feelings about a full-time staff for the board. If there is a full-time staff, its responsibilities should be very carefully limited; otherwise one would end up with two groups trying to run the Science Foundation. I am sure that the Board could profitably use more information which might be provided by a small amount of staff assistance. I would be very much concerned about a second layer of management, whether you say it is policymaking or operational, of the kind that is proposed by Dr. Walker.

Mr. DADDARIO. What did you have in mind, Dr. Wiesner, when you said the Director's hand ought to be strengthened?

Dr. WIESNER. In the Reorganization Act No. 2, in which the relationships between the National Science Foundation and the Office of Science and Technology were established, we also tried to raise the bureaucratic level of the Director, so that he had the same prerogatives and stature and responsibilities in the Government as other agency heads. We were not able to do this because of the fact that many of the responsibilities that an ordinary agency has reside at least normally by law in the Board, rather than the Director, and the Director is in many ways the agent for the Board, rather than the executive officer reporting to the President. In practice, actually, the Director has always been essentially an agent of the President, because the fiscal control which the President has is a pretty powerful form of control. So there has never been a problem, per se, as a result of this. But it is an anomaly—the Director essentially has all the responsibility, he gets all the blame if things go wrong, because the Board cannot exercise fiscal control or operations, but yet normally it has many of these responsibilities.

It would seem to me that it would be better to have provided the Director with these clear-cut operating responsibilities and limited the Board's responsibility to the policymaking.

Now, at the time of the reorganization some members of the Board felt very strongly that this is not right. I happen to feel that it would be a better, cleaner cut manner of operating if the Director had the full operating responsibility. But I know that at that time many of the members of the Board felt that the Science Foundation would not function as effectively. Some members of the Board even indicated that they would not serve on a board whose powers were greatly restricted. So it was an issue that would have been hotly contested if we had chose to do anything about it.

As I say, I, in the end, chose not to try to do it, because I thought we were right. I also felt that the problems that it would generate were more serious than the ones that it would cure.

Mr. DADDARIO. As the Science Foundation faces this ever-increasing role that you have been talking about, have we reached the point where the relationship of the National Science Board to the Director, and the Director's relationship with his staff should be reviewed?

Dr. WIESNER. The Board, itself, and the Science Foundation staff have had such a review. As a matter of fact, the Board has changed its structure. It now has three subcommittees, which I know you have heard about, established in an attempt to meet the growing effort. As far as I know, this is operating satisfactorily.

I am not aware of a need for a major overhaul of the structure but rather for an increased staff support within the Foundation. One other thing which I should have mentioned—the problem Dr. Wolfle talked about at considerable length—the matter of providing adequate information for making decisions. I think this is one of the more serious problems in the Government as a whole. The Science Foundation has, and has done reasonably well at this, particularly in recent years, but I think, seen from the Federal Government's point of view, the information about scientific activities and scientific manpower is not adequate. This is both a problem within the Science Foundation—the more information the Board and the Director and the staff have, the better they will be able to do their job—and for people at the presidential level, the Office of Science and Technology, the Bureau of the Budget, and other groups. I believe that the recommendations that Dr. Wolfle makes should be considered very seriously and we should make an effort to strengthen that particular aspect of the science management activity in the Foundation.

Mr. DADDARIO. Mr. Roush?

Mr. ROUSH. Mr. Chairman, I think Dr. Wiesner's off-the-cuff remarks are apparently the result of a great deal of wisdom and experience. They have made a real contribution to these hearings. Because they were off the cuff, perhaps some things crept into his remarks which he would not have placed in written testimony. I am very grateful for this opportunity to hear him.

You mentioned the behavioral sciences as one area which is not receiving enough attention. You also mentioned in this connection other agencies and their apparent lack of interest in this field. Is this is an area in which you feel the National Science Foundation should, or could, pay more attention?

Dr. WIESNER. Yes. It has been talked about a great deal, and, as I have indicated, in the last 4 or 5 years the Science Foundation has picked up activities in the behavioral sciences.

The closer one gets to the social behavior of human beings, the more skittish the Science Foundation has been about getting involved, because they are obviously getting further and further away from the physical sciences. Even the National Institutes of Health have been somewhat reluctant to get into these fields, and probably with good reason. These, in a sense, are beyond the normal interpretation of their missions, and there are fields where it is often hard to judge what is good and what is bad.

Mr. ROUSH. Isn't it, Dr. Wiesner, that we are going beyond the image which the people in Government and the people in education have of the National Science Foundation, rather than it is in going beyond its mission as has been set out by the Congress?

Dr. WIESNER. I think that the problem stems from the way we interpret the word "science" in this country. If we had the Russian or European interpretation of "science," which is just the development of knowledge, this probably wouldn't exist. All of us who have dealt with some of the foreign academies of science are surprised to

find historians, economists, political scientists, as full-fledged members of their academies of science. I think this is unfortunate in our country for this separation has generated a split among intellectuals which is undesirable. I think you are right, it is as much the image of what the words actually mean.

I think there is another problem that one ought to put on the table. At least in times past people have been concerned about doing research in social sciences because of their fears of Congress, a fear that Congress will think they are trying to manipulate public opinion or change the society. This has been very genuine, a fear for people having responsibility in big programs, and who don't want to get their agencies in trouble supporting what they regard peripheral activities. Anyone who is really candid with you will admit that this has been a factor in some elements of the social sciences.

Mr. ROUSH. My question has been prompted by an interest that I have in what I think is one of our real great national problems, and that is our crime problem. I have the natural interest of a citizen and a legislator, but this also has been stimulated by 4 years of activity as a prosecuting attorney. In the last couple of years, I have been trying to do some background work with the view of introducing legislation dealing with this great national problem. I have found that there is practically no research being done now in this area of human behavior.

I think it should be done. I am trying to find out who should be doing it, and why we haven't been doing more in this area.

Dr. WIESNER. I agree with you. At one time, while I was working down here, we became deeply involved in the narcotics question and we looked at the research and development activities attempting to understand the medical and social problems of addiction, and we were horrified to find that this was an area where no one was doing serious work in an attempt to understand either the biological or medical aspects of narcotic addiction. When I say "no one," I am exaggerating, but the amount of effort was comparatively small in comparison to the problem that we are facing, and I think this is also true of the field you are talking about. It is much harder to do research in these fields than in the physical sciences. They are much more complicated problems, so people shy away from them.

The image in these fields is also responsible for this. When I was working on the White House staff, people used to say the Government isn't supporting behavioral sciences adequately. I got us a group of behavioral scientists to form a panel for me to tell me what they needed. They didn't really know. They were so convinced they couldn't get support that they never bothered to try to get support. I think there is a "chicken and egg" problem in many of these fields. To a certain extent that has been resolved by support from the NSF and from the NIH, but I am sure more encouragement in these fields is badly needed.

Mr. ROUSH. That is all I have, Mr. Chairman.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. Doctor, you said at one point that the National Science Foundation was not playing the dominant role that it should. You also have mentioned your fear of bureaucratic control in this area.

Are you talking about this not being a dominant role purely in a quantitative sense?

Dr. WIESNER. No. But I think they are very much related, as I said. I think the ability to make policy and to influence policy and to determine what directions are followed is closely related to your responsibility for support. But I certainly was thinking at least as much about the role of the National Science Foundation in broad national policy in basic research as I was about fiscal responsibility, though I am certainly recommending that they be given a larger share of the fiscal responsibility for basic research as our programs grow.

Now, just to elaborate a little on one point of your question, I think the Science Foundation was initially given responsibilities to do things which we later concluded it should not have been asked to do. That is to have the coordinating responsibility over areas that are the responsibility of other departments of the Government. This is the role which, as an operating agency, as a funding agency, we concluded it could not really play. It can play an advisory role, a statistical-gathering role, a leadership role, but it cannot play the kind of Government-wide decisionmaking and coordinating role that was originally visualized for it.

Mr. CONABLE. This is the point of my question, Doctor. Do you feel the National Science Foundation should recapture some of this coordinating function that it has lost to the Office of Science and Technology?

Dr. WIESNER. I don't think so. I believe that the advisory and management structure that has been developed is satisfactory. You see, one of the problems, whether you are dealing with the Science Foundation or the Defense Department or the Atomic Energy Commission, is that once the agency becomes a funding agency it is a vested interest, and no matter how hard its director and staff try to be impartial, they must respond to internal pressures of their agency. One need that led to the development of the Office of Science and Technology and the Science Advisory Committee and their supporting whole structure was the President's need for some people whose loyalty was basically to him, and not to the missions or the agencies.

As the Science Foundation grows, its internal responsibilities will grow too, and it should be in a position to concentrate on those and be an advocate of its programs and its positions. To ask the Director of the Science Foundation to give the President impartial advice on problems that involve the Science Foundation is asking for a lot. But there is an even more important point. The President needs advice on a broad range of problems that involve science and technology that go way beyond the scope of the Science Foundation—foreign policy, defense, and so on—and the structure which exists is one that deals with the full range of the President's problems, and there the basic research activities are just a small part.

Mr. CONABLE. You also mentioned computers and the serious problems that our schools were having, essentially because they could not provide them because of the cost. Do you know if the National Science Foundation has made institutional grants for this purpose?

Dr. WIESNER. Oh, yes, the Science Foundation has funds for supporting institutions, but I think the problem is several times the scale of the Science Foundation's resources to deal with.

First of all, it hasn't the resources to provide the computers that are needed.

In addition, I don't believe anyone has thought through the second and more difficult problem which I mentioned, which is how to provide the resources to use computers in education, rather than in research. I am not even sure the Science Foundation would feel that that is an appropriate role for it, but it is a serious problem and it needs to be explored, or the country is going to be turning out youngsters whose education falls short of what it could be, by quite a bit, in this area.

Mr. Conable. One other question having to do with manpower: If the National Science Foundation continues to grow at the rate of 15 percent or more a year, do you see any problems relative to the availability of high-quality scientific personnel? Do you feel that we would be getting too much of our scientific manpower over into basic research, or is the supply growing sufficiently fast so that we won't have any shortages as a result of this?

Dr. Wiesner. This is a question about which it is hard to get good facts. The Government has tried, over the last half dozen years, to come to grips with this question. While I worked here I oscillated violently between believing that we were creating terrible manpower shortages and feeling that we were running a danger of creating an oversupply. Every time we got some new data, we oscillated between these two extremes. It is because the labor market is so flexible; that is, when you create more jobs by starting scientific activities you attract people who have been doing other things.

I think one has to admit that you generate sufficient demand you attract people who are inadequately trained.

I think the best judgment at the moment, as far as basic research is concerned, is that the country has enough trained people who can do good scientific work that we are not in danger of manpower shortages. In fact as the population grows, as our productivity increases, we should be glad to have these job opportunities for people to go into rather than to fear that we are draining off too large a fraction of the manpower into these activities. I must say this is a judgment that is based largely on looking at actual data and talking to people, rather than any hard facts that I could muster to prove my point.

Mr. Conable. That is all, Mr. Chairman.

Mr. Daddario. Mr. Davis?

Mr. Davis. Dr. Wiesner, I want to join with the sentiments expressed by Mr. Roush a few moments ago. I have thoroughly enjoyed your statement this morning and have gotten a lot out of it.

You have stated that the universities could use more computer facilities. Is it true that if industry had a lot more computers available, it could proceed with automation at a tremendously accelerated pace?

Dr. Wiesner. I don't feel competent to answer that question.

I will make some random observations, but I do it with a certain amount of hesitancy. I believe that some industries are really introducing computers about as fast as they have the ability to absorb the change. Certainly, the automobile industry is doing a lot of experimentation in this area. More of it is in the accounting and control activities than in the actual manufacturing process, at the moment.

But we also have computers running an increasing number of production machines. We are also using computers more and more in engineering activities. This is certainly true in the aerospace and electronic industries. The telephone industry is going over to switching that is computer controlled about as rapidly as it can.

On the other hand, there are many industries that are traditionally not used to employing technology at all, not only for automation, but just to make better products. It is only recently that automatic controls have been used extensively in ships, and I don't think they have been fully exploited. If we want to have a competitive marine industry, we should try to automate our ships so that smaller crews would be required.

Professionals who know about this—and I am not an expert in this field, tell me that in the shipbuilding industries overseas, in the Scandinavian countries, in Japan, and Germany, automation is employed more extensively than here, so that we are fighting against losing odds with obsolete technology and a higher cost labor force when we build ships here.

So there are clearly areas where one could do a great deal more.

Mr. DAVIS. The textile industry, for example, where there are lots of repetitive tasks, is pretty well subject to being automated, isn't it?

Dr. WIESNER. The textile industry is a strange one. I once had it studied. Some of the things which must be done, while repetitive, take a degree of intelligence that at the moment is beyond the sensors of computers that we know how to make.

This certainly will change. I was impressed by the fact that there wasn't much effort being made to couple computers and either looms or other textile machines. I tried to find out why this was, and came to the conclusion, I am not certain I am correct, it was a superficial look, and could have been wrong, that the structure of the industry with so many small units and very few large companies, was such that it was not possible to set up large-scale research and development activities. We tried on a number of occasions to stimulate something in this general field. Herb Holloman can show you a lot of scars that he acquired when he has tried to stimulate research in industry.

Industry didn't appear terribly anxious to be encouraged to do these things. I don't know why this was. Perhaps they are comfortable in their present position. In any event there was a fair amount of opposition to the Government's attempts to stimulate R. & D. in several industries. I don't honestly know how much can be done. Several times I have asked people in the clothing industry whether one couldn't develop a machine in which a computer directed a loom, so that the product was a suit, rather than a piece of cloth that then had to be cut and made into a suit. So far as I know, no one has ever tried to do this. There are probably a great many opportunities of this kind.

Mr. DAVIS. One situation that impresses me as being true is that with the progress we are making in converting our natural resources into the things we need with less and less human effort, less and less expenditure of manpower, two things happen: No. 1, the less privileged elements in the population realize there are enough assets to go around,

so it breeds unrest; and, No. 2, the set of values that our culture gives us becomes irrelevant. For both of those reasons it impresses me as imperative that far more effort go into the social sciences.

Dr. WIESNER. I think that is right. I think as far as the United States is concerned at least, this will be our No. 1 problem, providing we survive the arms race.

I believe that this matter of setting goals and ambitions among the kinds of life which technology permits is probably the key problem that we face, but whether this will come about as a result of social science studies or whether it has to come from spiritual understanding and leadership, or a combination of both is something I can't say.

We need to give a great deal more time and thought to this. I believe that the key to all of this is education. That is why I feel so strongly that more education, not just in science but general education, better understandings of ourselves, or history, the world we live in and the opportunities we have, are needed by everyone.

It seems to me the thing which we are recognizing now in this country is the point that Ken Galbraith made a number of years ago in "The Affluent Society," that we are no longer a nation that has to run on an economy of scarcity. We can do all the things we need to do to make a satisfactory life for all if we are intelligent enough to use our capabilities.

As our productivity increases and we have more people, we should be able to have more and better teachers, better medical care, better parks, et cetera. The opportunities for doing things are unlimited provided we can figure out how to use our resources properly.

Mr. DAVIS. That is all.

Mr. DADDARIO. Just following up Mr. Davis' questioning, Dr. Wiesner, you talk about the importance of education. The National Science Foundation science program support for fiscal year 1965 shows there is $280 million going into research, that includes $38 million in facilities, and $120 million in science education.

Is this disparity between these two cause for concern, especially in regard to the answer you gave to Mr. Davis' last question?

Dr. WIESNER. I haven't seen these budget figures, and I don't know what the money is for. What I am most concerned about is that we press as hard as we can in what I would call the innovation field. We call it research and education, but it is much more like engineering and development, trying to develop better curriculums, better understandings of how to teach, trying to use modern technologies that are available to the greatest extent.

I have not seen the 1966 budget breakdown, so it is conceivable that my worries would be less severe this year than they were last. Certainly during the period when I was deeply involved in the budgets of the Science Foundation I felt that the money for education was too severely restricted. The problem is, of course, that the Board and the Director have a whole series of objectives, and even though I may believe that education required more support, the Board felt that its single most important mission was the support of basic research.

In my opinion in that period we did not support educational research and development adequately, and I felt it was not supported adequately last year. I don't know about this year's funding so I am not in a position to comment on it.

There are tremendous opportunities here, and I believe that as a country we have been slow to recognize this fact. This is not in the NSF's primary responsibility, and I am not trying to blame them for the neglect. The Office of Education is much more at fault.

We spend about $30 billion a year on education. We once added up all expenditures by industry as well as the Government on research and development in education and it turns out to be a hundred million dollars; that is, 2 years ago we were spending only $100 million a year on the research to support a $30 billion industry.

No automobile company or other modern industry could survive with so small a share of its resources going into improving its product. It is only because its customers haven't any other place to go that the educational system gets away with this. If there were two school systems and some competition, I don't think this situation would persist very long. The Federal Government's responsibility arises because there are no normal market motivations to finance educational developments.

Mr. DADDARIO. The railroads have competition, but they probably put in about the same amount——

Dr. WIESNER. And they are slowly going out of business.

Mr. DADDARIO. Mr. Waggonner.

Mr. WAGGONNER. Dr. Wiesner, you spoke a moment ago about the shipbuilding industry in Europe and Japan. I had the privilege Sunday a week ago of visiting a highly automatic yard in Yokohama, Japan. I found a yard in Yokohama which is building large 150,000-ton tankers for American industry. Of course, it is much larger than anything else that it has done before. This yard only employs 1,200 people. They are working three 8-hour shifts a day. There are some areas automated and some not. They are automated to the extent that they have one central pipe rack. One can walk up and push a button for a piece of 6-inch pipe and down it comes. Then push another button after setting some control dials and it cuts a section at a 45-foot angle. Certain other areas are not automated at all.

I asked them why they had automated parts of the yard and not others. They said they had only automated those areas wherein the net return from automation would exceed the net return from utilizing manpower. I think they might have a simple guideline there that is quite good.

Dr. WIESNER. Of course, that situation is changing rapidly in Japan, because wages are going up very rapidly. I spent some time looking at the electronics industry in Japan 2 years ago, and I found exactly the same situation. The balance between automation and labor use compared to our best industry was on the side of using semiskilled labor rather than automation. But a shift is taking place there because the cost of labor is going up.

Mr. WAGGONNER. I agree with the previous comments that your remarks have been extremely good and helpful to us. Not that prepared statements aren't good, because they do paint the entire picture, but it does us good from time to time to have an impromptu commentary such as you have given us this morning.

Among the things you said is the fact that certain people over the country have grown impatient with the rate of growth that has been

experienced by the National Science Foundation. Would you tell me whether you share that impatience or not?

Dr. WIESNER. Certainly I do. But as a matter of fact, I would say this, I think the situation has been a great deal better in the past 5 or 6 or 7 years. This has come about as a result of the maturing of the scientific community and the recognition that, while the nature of the military support of research in this country was quite good, there were so many other objectives that one shouldn't depend entirely upon the military. The problem really was that it took so long for the Science Foundation to get off the ground rather than that the recent growth has been too bad. Even in recent years, though, the growth rate has been inadequate.

I think we haven't really fully compensated for the troubles of those early years. In other words, if there had been a reasonable growth in the first decade of the Science Foundation's existence, the situation would be a lot better than it is today. But, as I said, that we have gained a great deal of ground in recent years.

Mr. WAGGONNER. Of course, we all realize that the rate of growth which they have experienced had its limitations over and beyond their control in certain instances.

Dr. WIESNER. Oh, yes. I am not blaming the Science Foundation. I think other branches of the Government are much more responsible than the Foundation. The Foundation has known what it would like to do but it has not been supported.

Mr. WAGGONNER. You made the observation that perhaps the National Science Foundation, and of course I presume you mean their board and the director, should have more latitude in the international arena. You mentioned specifically cooperative programs. Did you intend to include as well that the National Science Foundation assume some responsibility in providing leadership in education abroad as they do here at home?

Dr. WIESNER. I didn't have education in mind but I think it should be included. I have seen, for example, in India the great impact of some of the National Science Foundation programs on education in the high schools and colleges in there, and this has come about in a very casual way. Much more of this would be helpful. The Science Foundation has not been in a position to give as much assistance overseas as desired.

This is a field in which assistance can be provided through other agencies involving the Science Foundation. For instance, AID can ask the Science Foundation for help. So I am not sure the NSF should be in a position to take the initiative. But there are areas in which the cooperation should really be undertaken primarily for scientific reasons rather than to assist the development of a country.

I think the spirit of the cooperation and the attitudes of the people involved in the cooperating countries will be very much better if it is done through the Foundation rather than through a development agency.

Mr. WAGGONNER. You commented as well that there were certain fields of research and educational advancements that you felt had been neglected in relation to others. Do you feel that the concept of the responsibility of the National Science Foundation has matured to the point that the Foundation, in conjunction with other available agen-

cies, can now establish percentages of money to be allocated to the various fields for which there is some responsibility?

Dr. WIESNER. I think so, yes. I think that the mechanisms for doing this are really fairly good at the moment.

Mr. WAGGONNER. In other words, we can relate the priorities of the needs of one field of research to another?

Dr. WIESNER. I don't like to use the word "priorities." I think it is very dangerous to say that one field of basic research is a higher priority than another.

Mr. WAGGONNER. Of course, that is what we have when we allocate percentagewise more money to one area than another.

Dr. WIESNER. Not necessarily, because there can be a field of great importance where the cost of research is not very costly.

If one were to try to relate certain fields of mathematical research where no equipment and just a few people are needed the field of high energy physics where every new machine doubles in cost, and we are now talking about machines that cost several hundred million dollars, we find how impossible this is. I wouldn't want to say that mathematics has a priority over high-energy physics.

We have to follow the method that Dr. Haworth indicated in his presentation, that is to examine the individual proposals and ask whether they are good or bad.

Actually, for administrative reasons it is necessary to allocate money by areas, and you could say in this sense that we are establishing priorities. But you be sure that you are not supporting relatively unimportant and poor quality work in one field while you are underfunding another.

I think fiscal allocations should be made in this loose and repetitive way, rather than by setting hard and fast priorities a priori. The Government process is sloppier and it is harder to do this way than if you just allocated sums of money because somebody's judgment said this field is more important than another. But I believe that the result is better.

Mr. WAGGONNER. You commented on the fact that you thought perhaps the ultimate answer to our problems would lie with education. I would to some extent agree with you, in that certainly we can find a direct relationship between our educational progress and our related accomplishments. This leads me to ask the question. Do you feel in view of what you have said that the National Science Foundation could not logically coordinate the scientific efforts which the Government undertakes—do you feel that the primary function of the National Science Foundation should be one of providing leadership, support and guidance to improve science education?

Dr. WIESNER. I think its primary function should remain the support and stimulation of basic research in the United States. But this is so closely related to the problem of science education that I think the two can't really be separated.

I think the Science Foundation's No. 1 and primary mission ought to be to preserve and stimulate the development of our basic scientific activities, our national basic research effort. This can't be done without education in the sciences. So I think they are inseparable. Furthermore it should be realized that most graduate research is also graduate teaching.

I wouldn't like to give the education a priority higher than the science, that is, the science and the research itself.

Mr. WAGGONNER. I am not going to ask that you attempt to answer this question here, but I would like for you to provide an answer for the record to this question.

Having asked the question about whether or not the National Science Foundation should have primary responsibility in providing leadership, support, and guidance to improve science education, you have commented on their inability under existing organization to provide the coordination that some people feel they should provide. Will you provide for the record what you think the end result of reorganization along these lines would be?

Suppose that the President has a science adviser in the capacity in which you once served, and in which Dr. Hornig now serves; suppose that the Office of Science and Technology was combined with the National Science Foundation; and suppose the President's science adviser served as Chairman of that Board; and suppose the National Science Foundation has a Director, as they now have. In addition, it is understood that this talked of reorganization was charged with the responsibility of not only providing leadership and guidance in the field of science education, but also of coordinating the scientific research of the Federal Government, giving special emphasis to using the capabilities of the mission-oriented agencies, such as the National Institutes of Health, the Department of Defense, the National Aeronautics and Space Administration, et cetera. Would you provide for the record what you think would be the pros and cons of such an organization, and what would be the end result in your opinion?

Dr. WIESNER. All right.

Mr. WAGGONNER. Thank you, Mr. Chairman.

(The information requested, is as follows:)

As I have already stated, I believe that the position of the Special Assistant to the President for Science and Technology should not be combined with that of the Director of the NSF. Many people have proposed some such consolidation. One popular and often advocated, scheme is the establishment of a Department of Science which would have responsibility for all basic research financed by the Federal Government. The agency head might be given Cabinet status and would also serve as the President's Science Adviser. Then the President's Science Advisory Committee and the President's Special Assistant for Science and Technology would no longer be needed because the coordination they provide would be assured automatically. The present structure leaves most of the decisionmaking and management of Government scientific programs up to the individual agencies, and arrangement which I am in favor of.

While I believe some of the arguments for a Department of Science have an element of validity and would support an effort to bring together some governmental activities that are not closely tied to agency missions, the proposal to collect all Government-supported basic science into a single agency is not the answer. First, intimate contact with basic research is essential for those agencies whose missions depend significantly upon technology.

Second, the new Department would be a major proponent of scientific programs, and its Director could not be expected to give objective advice to the executive branch on issues in which the Department had a major stake. Nor could he successfully serve as critic and judge of the technical programs of the other departments. The role of an independent Special Assistant for Science and Technology would be made more difficult by this move.

I also have a subjective objection to the proposal. As I stated earlier, I am afraid of too much centralization and control. I believe that the multiplicity of agencies funding basic research, and in a a sense competing, has been a significant source of strength in the U.S. scientific program, and is a feature which should be preserved.

Mr. DADDARIO. Mr. Brown.

Mr. BROWN. I would like to ask just one question. With regard to this need for increasing emphasis in the two areas that you have mentioned—the engineering sciences and the social sciences—do you think it would be helpful specifically to delineate in the National Science Foundation Act the responsibility of the National Science Foundation within these areas?

For example, now the mandate in the social sciences is merely included under the term "other sciences," and there is no specific delineation.

Dr. WIESNER. I don't know how to answer that question. If I was serving in an official capacity, I would say no, we can do it, and we don't want to be ordered to do it. On the other hand I believe that stimulation from a group such as yours can on occasion get something done that wasn't being done.

I would think that one wouldn't have to make a change in the Science Foundation Act, but if the committee felt this was an important task and said so, the Science Foundation would undoubtedly respond. You should really ask Dr. Haworth the question rather than me.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. Dr. Wiesner, you covered a very large number of subjects and, as has been said by the chairman you have done an excellent job. I agree with many of your remarks.

I have some very specific subjects that I want to take up.

In regard to the role of the National Science Board to the Director, and the Scientific Adviser to the President, what is the channel of fiscal control? Suppose, for example, that the Office of the President decided that the budget for the year should carry certain projects and the Board concluded to the opposite. I can imagine such projects being canceled out; that is to say, the solution might lie in everyone backing down rather than carrying this to conclusion in a positive way. Have such contentions occurred in the past in the operations of the National Science Foundation where fiscal control is exercised directly out of the Office of the President or the Budget Bureau at least through or passed the Board?

Dr. WIESNER. I doubt that fiscal control has ever been used to stop a specific project that somebody objected to, but fiscal control is exercised all through the Government by the President through the Bureau of the Budget, and for scientific activities, by the Bureau of the Budget and the Office of Science and Technology, largely because the projects that are submitted to the President usually cost 40 or 50 percent more than the President feels the budget can stand, and this is just as true in science as——

Mr. VIVIAN. Is the Board independent in any real sense?

Dr. WIESNER. No. The budgets are normally supported by the Director of the Science Foundation having been approved by the Board in advance. The Director of the Budget Bureau works with the Director of the National Science Foundation. Usually, when adjustments have to be made, these are made with cooperation. Sometimes the Bureau of the Budget or the Office of Science and Technology will have a different view about where changes ought to be made than the Director of the Science Foundation, but this is also true in dealing with the Atomic Energy Commission and the Department of Defense too.

Mr. VIVIAN. In the typical situation, is there a direct line of responsibility from the President to the agency's head and from the Bureau of the Budget?

Dr. WIESNER. As the Science Foundation operates, it is no different. The Director's relationship to the President and the Bureau of the Budget are essentially the same.

Mr. VIVIAN. The Director does not report to the Board in the context of budget actions?

Dr. WIESNER. He certainly has the Board approval. But the Board does not submit the budget to the Bureau of the Budget.

Mr. VIVIAN. I ask these questions because of the comment you made that you thought it might be well to make the Board an advisory board. I thought this would be a wise step to clarify what the reality is.

Dr. WIESNER. Just to present the other side of the question, because I think there are some very real issues, even though you and I are on the same side of the question.

The reason for the establishment of a Science Foundation rather than a Department of Science or some other move, the normal Federal agency operating, was to isolate the support of science from direct Federal control because of the fear that there could be too much governmental direction, domination, or control of our academic institutions through this very powerful device.

As a matter of fact, as you probably know, the original proposals for the National Science Foundation called for the creation of a very much more isolated Foundation than the present one. Board members feel that with the lines of authorities now established, the academic community is guaranteed a clearcut formal course through which, without going to the President, or the Director, they can intercede if they want to, and I think this is an issue that can't be brushed aside lightly.

Mr. VIVIAN. Has the power been exercised?

Dr. WIESNER. Under the present setup, the Board could go directly to the President or even directly to the Congress to complain about the operation of the Foundation. I don't know what the situation is with regard to the director, since he is appointed by the President and not by the Board. This is one of the problems that we were trying to resolve. I think any change must take into account the problem of providing a mechanism which is responsive to the desires and worries of the academic community. These are not just minor worries. One of the great dangers in modern society is increasing centralization, increasing control, and one ought to do everything you can to fight this consistent with the kind of evolution we want to see in our society.

Mr. VIVIAN. I don't dispute your concern, but I would like to shift to some other questions.

The relationship between the National Science Foundation and the Office of Education and the National Institutes of Health remains unclear to me.

The NIH has a very similar role and function, except that its concern is primarily in the biological area. It is not obvious to me why the two in some respects are not consolidated.

Likewise, the Office of Education has a relationship to both of these. However, I have no clear conception as to how these are related. Do you know?

Dr. WIESNER. I think I do, although I must say things change and I gather there is now a new coordinating committee for education that I know very little about.

First of all, the National Institutes of Health has no legal responsibility or authority for education. In fact, this is one of the flaws in the present arrangement. The NIH is not authorized to engage in educational activities, which is obviously very foolish, because whenever you support research in a university, you are engaging in an educational activity, but their mission is to support research in the health-related fields, and other groups have the responsibility for medical education.

I think this is something that one should examine. One can make a case for putting together the National Science Foundation and the National Institutes of Health and maybe one or two other organizations. This would have some advantages and it would also have some disadvantages because it would create a bigger bureaucracy. It in particular would create a situation in which there would be fewer independent supporting agencies, something that I don't happen to like.

The relationships between the NIH and the NSF have been extremely good through the years. Because the NIH is mission-oriented, its funding has been more generous than the NSF. The NSF has always been quite happy to see the NIH support those things that are health related and concentrate its support in other fields. To my knowledge, the degree of coordination between these two organizations has been good and they have worked together very well. It has the advantage that the NIH has invented organizational forms which were different from the NSF, so we have had experimentation that we wouldn't have had if we had only one group.

The problems of the relationship of both of these groups to the Office of Education is more complicated. The Science Foundation, one could claim, got into the educational business by default. If the Office of Education had been more aggressive, and with an interest in science, one might not have needed the NSF programs, but because it is much more closely related to science and science problems than the Office of Education has been, or I suspect ever will be, the Office of Education must deal with the full gamut of education including some enormous pieces such as the elementary and secondary schools. It is probably a good thing to have the NSF involved in science education too, providing that a high degree of coordination exists.

When I was the President's science adviser, we had an informal educational committee that included the Commissioner of Education, the Director of the National Science Foundation, the Chairman of the Atomic Energy Commission, the Director of the Bureau of the Budget, the Director of Research and Engineering in the Department of Defense, National Aeronautics and Space Administration, and several other agencies and myself which used to meet quite frequently to talk about the educational problems that involve all of these agencies.

I have the impression that this has been formalized into a new committee which the Commissioner of Education chairs, but I am not certain that this is precisely the origin of the present committee.

In any event, there have been continuing coordinating activities in this field.

In the field of educational research and development, there was and still is a panel sponsored jointly by the Commissioner of Education, the Director of the National Science Foundation, and the Office of Science and Technology, and this group has stimulated many of the activities which are now going on in educational research. As far as I know, this group will continue to function indefinitely.

One always gets into the debate about whether line organizations or coordinating efforts are better in a thing as big as the Federal Government, and I don't claim to know which is better, but I happen to prefer diversity.

Mr. VIVIAN. Mr. Chairman, I have a few more questions, but I think I can take them up later with Dr. Wiesner.

Mr. DADDARIO. Mr. Chairman.

Mr. MILLER. I am sorry I couldn't be here earlier for your testimony, Doctor, but the full committee is holding hearings on a subject that I think is close to your heart, the metric system.

I want to welcome you back and say that I am very happy that you are here.

Mr. DADDARIO. Dr. Wiesner, I want to thank you on behalf of the committee. If there is one reason for a better relationship between the Congress and the scientific community, and between the Congress and the executive branch, it is just because you played a great role in that regard. It is with ever-increasing regard for your participation in this process that I welcome you here and am pleased by what you had to say. It has been of outstanding value to this committee, Dr. Wiesner. I think that has been demonstrated by the remarks made by the members, and by their attendance this morning.

I would like also to ask if I might submit some other questions to you in some areas that we have not yet had an opportunity to cover this morning? [1]

Dr. WIESNER. Fine. Thank you very much.

Mr. DADDARIO. This committee will adjourn until tomorrow morning at 10 o'clock, at the same place.

(Whereupon, at 12:01 p.m., the subcommittee adjourned to reconvene at 10 a.m., on the following day.)

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[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

NATIONAL SCIENCE FOUNDATION

SEMINAR ON MANPOWER AND TRAINING

WEDNESDAY, AUGUST 4, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. This meeting will come to order.

I am pleased to welcome on behalf of the committee a most distinguished group of men who have consented to come here today and discuss with the committee a problem of great importance to the country involving the proper utilization of our scientific and technical manpower. We plan to discuss what the present manpower situation is; what are the statistical problems involved, and what part the National Science Foundation plays in this scheme of things.

The committee is pleased to welcome this morning Dr. Leonard Lecht, Dr. Bryce Crawford, Dr. Bowen C. Dees, Mr. William Douglass, Dr. James Killian, Dr. Frederick Terman, and Dr. M. H. Trytten.

We will proceed alphabetically to hear the opening remarks of the panelists. However, Dr. Dees, who represents the National Science Foundation, will be the last to speak in order that he may first hear the comments of the other members.

We will, therefore, start with Dr. Bryce Crawford. We are anxious to hear from you, Dr. Crawford, and to the other gentlemen as well. Will you proceed, please.

STATEMENT OF DR. BRYCE CRAWFORD, DEAN, GRADUATE SCHOOL, UNIVERSITY OF MINNESOTA

Dr. CRAWFORD. Thank you, sir.

It is a pleasure to be here, and I am very happy to join in this seminar. We will be talking not only, we hope, to help the members of the committee; we are sure to learn from each other in our interaction on these particular problems.

I was not planning to address my initial comments to any of the statistical problems or the problems of the numbers of adequately trained scientific personnel we would need. The other members of the panel are far better equipped than I, I believe, to contribute that type

of information. As a matter of fact, speaking as the graduate dean of the University of Minnesota, I think it is generally known any attempt to get statistics on graduate school operations is one of the most difficult and woolly tasks in higher education, simply because of the great variety of the types of graduate students, the great variety of their degree of involvement in their graduate school activities, and the great variety of types of programs in graduate schools. I know that Dr. Trytten would agree with me on this fact.

I did think, however, that I might most usefully contribute some qualitative remarks on the subject of adequate training and how this can be done, and one particular aspect of the adequate training problem which involves me very deeply in my capacity in the graduate school at the University of Minnesota. This is the complex of problems: first that of recruiting graduate students, especially in the scientific and engineering fields, supporting them, giving them the best possible graduate school experience; against that we have the question of giving them research opportunities; against that we have the question of using these graduate students as teaching assistants and thereby aiding in the training of undergraduate students.

In very general ball park figures, at the University of Minnesota we have about 1,000 graduate students—out of the total of 7,000 I should remark—we have about 1,000 who hold teaching assistantships and therefore are taking part in the teaching enterprise. We have another roughly 1,000 students who hold research assistantships and derive financial support for their graduate study by, if you will, being paid to carry out their research studies. We have a smaller number, running to some 600 or 700, who receive support from so-called nonservice appointments. These are fellowships, some of them, naturally, National Science Foundation fellowships—from our viewpoint we wish there were more—some of them NSF traineeships, NASA traineeships, NIH fellowships, and various locally supported fellowships.

I would like to address a few remarks to the interaction of these three types of graduate student activity that I deliberately placed in opposition, and what I would like to do is to destroy that image of any opposition. I spoke of nonservice fellowships, I spoke of teaching assistantships, and I spoke of research assistantships. We sometimes hear a complaint that there are too many fellowships, that we don't need more fellowships. This is, I think, just numerically, a little hard to support. If you consider the fact that there are roughly a hundred thousand graduate students in the scientific and engineering fields, a little over that actually, and then you look at the total number of NSF fellowships, which is about 6,000, or even the total number of National Defense Education Act fellowships, which is some 7,500, you realize this is a small fraction of the total number of graduate students in these areas.

We also sometimes hear that research grants, research assistantships are pulling away good graduate students from the teaching enterprise, and this is sometimes viewed as a bad thing. The point I would like to make is that the graduate student enterprise partakes of the apprentice system. He gains his education not just by classroom

study and by listening to lectures but also very essentially by taking part in a research program. So the thought that research and education are somehow separable, or even worse opposed, is one that I think cannot be spoken against too often. The research assistantship in my opinion is just as useful a method of recruiting and helping to train graduate students as any other.

Also intertwined in this operation of graduate study is the teaching aspect, and it certainly is a valid proposition that serving as a teaching assistant, taking part in the education of undergraduate students, is of great benefit to the graduate student himself.

Here again, properly operated, we have an apprentice system which not only benefits the apprentice, but extends the range of operation of your master teacher, and it is, I think, an essential component of the total graduate school operation.

Ideally, I think we would like to have a system whereby all of these threads were intertwined and where any graduate student who carried out his research studies took some part in the teaching program, both for his benefit and for the improvement of our capacity to train well increasing numbers of undergraduate students; and also he should have an adequate amount of nonservice support at some point in his career so he can take an undistracted slice of time to devote to a concentrated endeavor in his own studies.

The National Science Foundation in particular and the various other programs which help us to recruit and support and encourage graduate students, have moved toward the concept of permitting their fellows to take part in the teaching enterprise.

My main point here is I wish they would go a little further in that direction. I would like to see an arrangement, which I am sure can be worked out, whereby fellows of all sorts, not merely NSF fellows, but all types, including our locally supported fellows, were not merely permitted to engage in the teaching enterprise but were expected to. I would not want to say mandated because individuals differ, and to make a requirement that every graduate student take part in active undergraduate teaching would certainly cause some individual cases of ineffectiveness.

I would like, Mr. Chairman, to let that be my initial contribution to the seminar.

Mr. DADDARIO. Thank you.

I would like to ask just one question. In your closing remarks you mentioned the idea that the teaching should be expected but not required. Do you mean to draw a line in those cases where a person may not be helped by the teaching role, and that in these cases the teaching requirement may be waived?

Dr. CRAWFORD. Yes, sir. I think you might with some slight exaggeration say that at present the initial assumption is that a fellow will not necessarily take part in any of the teaching enterprise, but he may. I would like to reverse that and say that the initial assumption is he will take part in the teaching enterprise, but in individual cases this would not be an absolute requirement.

Mr. DADDARIO. Thank you very much, Dr. Crawford.

Mr. Douglass.

STATEMENT OF WILLIAM A. DOUGLASS, PRESIDENT, CAREERS, INC.

Mr. DOUGLASS. Mr. Chairman, I can say initially it is very pleasant to be here.

I think my position in this field is somewhat different than the other members of the panel, in that they one way or another seem to be associated with the education process. Our company inherits these people after they have completed their education.

My company, for over 15 years now, has met some two and a half million college seniors as they go out into their first jobs. In the field of engineering and science we have systems which allow us to apparently meet them again and again as they develop in their careers. In other words, ours is an employment clearinghouse. The perspective is different in that we are working on employers' problems. I might point out that the problems here are those of Government agencies as well as of private firms.

My invitation to appear here today with this panel and before the distinguished members of this committee is both a pleasure to me and a warning. The pleasure is derived from the too infrequent opportunity I am provided here to step back a little bit from day-to-day involvement in manpower subjects and to join you people in thinking about some of these subjects. The warning is the challenge that such opportunities present to us all, and that is that we really have something significant to say and hopefully something significant will come of what we have said.

Let me illustrate this warning. I think it is a very real one. In September of 1963 I invited to New York a panel of manpower experts to discuss the proposition "Engineering—a Profession in Trouble?"—with a question mark on it. We printed a transcript of that debate and received wide circulation. This May of 1965, under the auspices of the IEEE, I again set up a panel on the same subject. As a part of the press notice to many technical publications there was included a transcript of the first panel of 1963. You can imagine my surprise yesterday when I picked up the July 1965 issue of one of the technical publications that had received this release and found that the 1963 transcript had been interpreted by them to be the 1965 discussion. I read the 1963 transcript in haste with potential horror to see if we had dated things, because there was the big dip in engineering needs in late 1963. I didn't see anything in that which they reprinted which couldn't be said again today and still be the problem it was then. But that is only a 2-year-old study.

I was down here before this same committee in 1959 on very much the same subjects that we are hitting today. I gave what I believe was significant testimony because it pertained to the utilization of technical manpower, and I said, with a feeling of guilt then, as I do now, that if some 60,000 engineers and scientists applied to my concern for change of job in the last 2 or 3 years, there is certainly something going on in the field that at least needs to be discussed.

I say significant, because the committee itself had sufficient interest to hold additional hearings on the subjects which I proposed, and they even wrote a bill. The bill is very much to the heart of our discussions here today, I think, because it proposed congressional funding of a program for far better manpower statistics than any of us possess.

I re-read those hearings this past weekend and quite honestly, if you threw away the dateline, I think much of it could be equally cogent today.

I realize that my 6-year study can be topped by all other members of the panel because I am sure that most of you could cite things that were said 20 years ago, problems which you identified then which are still problems now. I wonder if you are satisfied that having identified these problems, enough has been done to research whether they really exist or not, and if they do exist whether enough has been done to face them and perhaps try to solve them. Demonstration projects, I think, are at least a timid way to try and find out answers to problems. The worst you can do is find out you are wrong.

So you can perhaps sense better than I both my privilege and my urgency in being here. Panels like us can touch on so many fascinating subjects—technical obsolescence, continuing education not only for the successful [the Sloan Foundation fellowships I think at MIT are a great step toward taking people who are past 35 years of age and giving them a reeducation. But I wonder if this can't always be done also with some of the unsuccessful, those who are technically obsolescent, those who have educations which are no longer applicable to the engineering needs of today] graduate study, mobility, the proper use of skilled aliens. [The last is something that hits us very hard as we get many alien engineers and scientists. They are virtually useless to all of our companies who are in any way engaged in the security business. I think that the aliens themselves wonder sometimes how Dr. Von Braun ever got in here, because somehow or other we cleared him and we can't clear these fellows.]

But I felt in 1959 and I feel today that each of these subjects we could talk about is going to be somewhat inconclusive until we have gone a great deal deeper in our knowledge of the problems behind these subjects, manpower research, and until we have done a great deal more to try to create solutions to these problems than we have today.

I thank you very much.

Mr. DADDARIO. Thank you, Mr. Douglass.

Our next participant is Dr. James Killian, who is the chairman of the Corporation of the Massachusetts Institute of Technology. Dr. Killian has worked with this committee and with the Congress and the executive branch for many years. He was the first science adviser to the President, and holds a unique position in the eyes of the entire scientific community.

We are anxious to hear you, Dr. Killian.

STATEMENT OF DR. JAMES KILLIAN, CHAIRMAN OF THE CORPORATION OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. KILLIAN. Thank you, Mr. Chairman, and gentlemen. It is a privilege to be here.

I would like to mention several somewhat different topics as possible pegs on which we might hang some discussion later on.

First of all, I would sum up my view of the supply-and-demand situation of scientists and engineers by saying that in the years ahead shortages are more likely to occur in science, engineering, medicine, and mathematics than in the humanities, the social sciences, and law.

This continuing demand for increasing numbers of high-quality professional people seems to me to be a prime factor in planning the future of the National Science Foundation.

Recently I chaired a committee of the National Academy of Sciences which reported to the President on the utilization of scientists and engineers. This report concluded that contrary to many public statements we run the risk of having too few rather than having too many students elect to study science and engineering. And the report also noted that the percentage of our college population committed to science and engineering has been such that these fields are not robbing the humanities or other fields at the present time as we sometimes hear.

This whole business of projecting demand and supply is a very tricky one, but this is a way that I would sum up my present judgment.

The next topic that I would mention is this one that has been touched upon by Mr. Douglass, the problem of having adequate information.

There have been a number of study groups, both within and without Government, that have repeatedly recommended giving a single agency or office in Government specific responsibility and authority for coordinating the various efforts of Federal agencies to provide an adequate and continuing body of information on scientific and technical manpower.

The Select Committee on Government Research made this recommendation, the National Academy Committee made this recommendation, and there have been others.

To the best of my knowledge this has not been achieved. The responsibility, of course, probably vests, as I understand it, in the President's Committee on Manpower at the present time, and probably there have been a matter of priorities there. Currently the National Science Foundation and other Government agencies are collecting great amounts of data on manpower, but there is yet no central place where it can be brought together and expertly made useful to decisionmakers. We need more interpretation of this data and more projections, taking into consideration future alternatives that may affect the situation.

While I do not suggest specifically that the National Science Foundation assume this function, as a major source of information, a very effective source, it must have a partnership participation in such a central effort. Above all, we need a single office in Government charged with the responsibility for keeping under continuous review the supply and demand of science and engineering manpower, and with the responsibility to present it in a form that will facilitate action and decision.

My third topic is to remark that looking back on the Foundation's history I would conclude that the most important thing that the Foundation might have done that it did not do was to initiate much earlier its program for aiding potential centers of excellence and creating new innovative programs.

I hasten to say that this failure should not be charged to the National Science Foundation because I think all of us in the community of science and engineering and the educational community failed to appreciate the importance of getting started on such a program early enough. It takes a long time to build these centers and to achieve

for them the right tone and atmosphere as well as the necessary resources.

We need additional centers of strength now. We will need them more in the future. So far we have been too dependent on a few centers where graduate students can be trained in an environment of excitement and excellence. While it is unquestionably desirable to achieve a geographical distribution of such centers, it seems to me that the overriding objective, and this is a view that you have certainly heard, should be to gain some increase now in the number of centers where first-rate talent can receive first-rate training.

The present centers of strength cannot turn out enough high-quality graduates to meet the growing national need, at least they cannot without growing too big. These additional centers must be aided without penalizing the present ones, and we must be realistic in realizing that only a small number can be created within the immediate years ahead. The limiting factor, of course, is faculty.

My final statement is to remark that the Foundation has made a breakthrough in the improvement of American education by the support it has given to curriculum development and teacher training. This has been to me one of the most impressive accomplishments in American education in the last several decades. There is still, however, a big and urgent job to do, and the Foundation's program in my judgment should be expanded to support more work in curriculum development, curriculum reform, and teacher training in the field of the sciences. When a breakthrough of this kind occurs, we should not fail to explore it fully.

There are a number of other topics that might be touched upon that seem to me to be important in the manpower picture, but I will rest with mentioning these specific topics at the present time.

Mr. DADDARIO. Thank you, Dr. Killian.

Dr. Leonard A. Lecht, Director of the National Goals Project, National Planning Association, is our next participant.

STATEMENT OF DR. LEONARD A. LECHT, DIRECTOR OF THE NATIONAL GOALS PROJECT, NATIONAL PLANNING ASSOCIATION

Dr. LECHT. It is a pleasure to participate in the work of the committee. What I have to say I say as an individual and my views are not necessarily those of the National Planning Association.

It is interesting to note that between 1953 and 1963 spending for R. & D. roughly tripled in the United States. Most of this increase has been the result of public spending in pursuit of national objectives in three areas—defense, space, and atomic energy. These three areas together accounted for about seven-eighths of all public R. & D. spending in fiscal 1962 and 1963.

The National Planning Association has attempted to estimate the dollar cost of pursuing national objectives in the 1970's. R. & D., of course, ranks as one of these objectives, along with improving health and education or rebuilding our cities and our transportation system.

We estimate that the pursuit of national objectives would involve R. & D. spending in 1962 dollars amounting to $39 billion by 1975. This means an anticipated increase in R. & D. spending of almost two and a half times between 1962 and 1975, from $16 to $39 billion.

In terms of GNP, R. & D. expenditures are projected in our estimates to increase from 3 percent of GNP in 1962 and 1963 to 4 percent of the trillion-dollar GNP anticipated in 1975. And while spending for R. & D. related to defense, space, or atomic energy is expected to continue increasing over the next decade, the largest percentage increases are listed in what we might call the civilian economy area in health, in transportation, in the many industries conducting little research, and in coping with such problems as air pollution or the need to increase the Nation's and the world's supply of usable fresh water.

About a year and a half ago the Committee on Utilization of Scientific and Engineering Manpower asked us to translate our estimates of the dollar expenditures for national objectives into estimates of the scientific and engineering manpower requirements they implied in the 1970's. We are currently preparing similar estimates as part of a study of manpower requirements for national objectives we are conducting for the Office of Manpower, Automation and Training of the Department of Labor.

Our projections for the Committee indicates that achieving the Nation's objectives would involve a 125-percent increase in the number of scientists and engineers in 1975 over the 1960 level. Allowing for the replacement of losses due to normal attrition, this works out to an anticipated increase in the pool of scientists and engineers of 1¾ million between 1962 and 1975. The largest percentage increases are listed for education and for the space program, with the absolute increase in education being far greater, of course, than for space.

Like all projections these estimates are speculative since they continue recent tendencies and expectations into an unknown future. Yet the underlying tendencies the projections reflect have significant implications for national science policy, for education policy, and in other areas.

One of these implications is the need for national planning to take into account the impact of national priorities on the supply and demand of technical manpower in policy decisions. This kind of planning would identify the scientific and engineering skills which will be required for all our major national activities, public and private, and it would do so on a continuing basis. It would also involve projecting these needs several years ahead and delineating the magnitude and timing of the technical manpower requirements before they arise. This type of planning could be part of an overall mechanism for program appraisal established in the Executive Office of the President.

If we are to produce the numbers of scientists and engineers the nation is likely to need in the next decade, a balance must be struck between the supply of scientists and engineers added to the manpower pool by the educational system and the demands for additional manpower from the pool.

Since the demands for manpower for college and university faculties, for national security R. & D. or for civilian economy R. & D. are competing demands at any particular time, an allocation balance must also be struck if all of the competing demands are to be served.

Until about a decade ago these balances were largely determined by the market. While the market is still a significant factor, the great change in the past decade has been the far greater role of public

policy in influencing the demand side of the balances, and more recently, and probably to a lesser extent, in influencing the supply side.

Devising public policies to achieve satisfactory balances in these areas would involve the kind of planning we have mentioned. For intelligent planning, in turn, we need far more research to improve our understanding of the factors that influence the demands for technical manpower and, even more so, the supply.

The information at our disposal has been growing. The work of the National Science Foundation, the work of the National Register of Scientific and Technical Personnel, and surveys of the Department of Labor have given us a good bit of basic source material and of factual data. While we have much more and better information than we had five or ten years ago, the gaps in our understanding are still of considerable significance.

To cite one example, since the late fifties, the percentage of all bachelor's degrees accounted for by bachelor's degrees in engineering has been consistently declining. This percentage has fallen from 10 percent of bachelor's degrees in 1958–59 to 7½ percent of all bachelor's degrees in 1962–63. Yet we don't really know why this decline has taken place since we know too little about the determinants of occupational choice in our society.

Or, the possibilities for achieving large-scale increases in "civilian economy" R. & D. will be significantly affected by the degree of convertibility of technical manpower with experience in defense and space R. & D. to R. & D. in such areas as mass transportation or pollution control. It is also likely to be affected by the convertibility of the techniques, such as operations research, which have been so extensively developed in the defense or space programs.

To date we have few studies of the experience of scientists and engineers who have moved from one of these areas to another, or studies of the experience of firms with substantial research capabilities which have attempted to use part of these capabilities in the new and growing areas of civilian economy research.

To summarize, our Nation will need more trained and educated manpower in many fields in the next decade, including many more scientists and engineers. The prospects of success in increasing the supply of technical manpower and utilizing it effectively would be substantially improved by taking positive steps to develop and expand manpower research and planning as a basis for policy.

Mr. Daddario. We will hear now Dr. Frederick Terman, vice president of Stanford University.

STATEMENT OF DR. FREDERICK TERMAN, VICE PRESIDENT, STANFORD UNIVERSITY

Dr. Terman. Mr. Chairman, members of the committee, trained manpower, particularly manpower trained in the sciences and engineering, represents what is probably the most important natural resource that this country possesses. In science and engineering particularly, trained manpower is the basis of the technological development that makes the U.S. economy so distinctive and which underlies both our high standards of living and our military security.

Now I am going to direct the rest of my remarks primarily to the engineering, mathematical, and physical science area, passing over the health field, which is handled separately, and I think is really in much better shape from the point of view of the needs of our country than is the case with the physical sciences and the mathematical sciences and engineering.

During the last 15 or 10 years there have been a whole succession of waves of concern regarding the shortage of engineers and scientists in this country, particularly the shortage of engineers. My feeling, however, is that much of this concern has been misdirected into a concern about numbers, sort of a head count, vis-a-vis the Russian numbers in relationship to our numbers.

The few studies that have been made, in at least my own qualitative judgment and that of some of the people I have worked with, such as the Gilliland Panel on Manpower, are pretty much in agreement that we have never really suffered from a critical lack of warm bodies stamped with the B.S. label, but we do now have, and we have continuously for at least 25 years had, a continuing shortage of engineers and scientists who lack higher levels of training that are really needed—higher levels of training combined with high ability. There is a real shortage and a continuing shortage in that category of people. This is particularly true in the mathematical sciences and engineering where something like 6 percent and 4 percent, respectively, or about 1 in 15 or 1 in 25, of the bachelor's degrees go on to complete work for the doctorate degree. The situation is better in physics and chemistry where about 15 and 20 percent of the bachelor degree people do ultimately receive the doctor's degree. That means something like 1 in 5 or 6.

Now for those capable of leadership and of making significant contributions in our technological world as it exists now, a 4-year college course ending in a bachelor's degree is simply no longer adequate for a career in engineering or science, at least not a career that makes full use of the abilities of the more capable people.

At present far too high a proportion of our outstanding young people in these areas, and particularly in engineering and science, discontinue their formal training before they have obtained all of education that would benefit them and enable them to maximize their contribution to society. As a result, today's manpower pool in technology and science is a good deal more adequate in quantity than it is in quality as far as meeting our needs is concerned.

All too often employers, and this is not just defense employers, but employers either for civilian or the defense or space needs, will settle for a man with a bachelor's degree training in filling a billet when what they really wanted and needed was a man with a master's degree training, and they will settle for a master's degree training—they are forced to settle for a master's degree training, when what they really needed and know they need is a man with a doctor's level of training. These people with the higher degrees are just simply not available in the numbers in which they could be absorbed usefully.

This situation downgrades the effectiveness of our industrial economy, and it weakens our space and weapons program. As a result of quality of personnel that is inadequate to do the job, projects—this is not just military projects but all projects—will tend to take

longer to complete than they should, and this, of course, means they tend to overrun their costs. When personnel is of inadequate quality, projects often fall substantially short of achieving their desired objectives, and sometimes get canceled because the problems that are involved don't get solved, or drag out so long as to lose timeliness.

In both the civilian and Government programs involving newer fronts of technology, the difference between success and failure or between a rapid development and one that drags out so long that its real usefulness vanish is determined by the success in solving the more difficult problems involved, and here the quality of the people that are working on those problems is all important. The lack of high-level ability combined with adequate training to utilize that ability cannot be compensated for by simply putting more people on the job.

This competition—and incidentally it is an international competition, broader than just the military arms race with Russia; the quality of manpower is as important in this area of international technological competition as in an international track meet. How many people does our Nation need on our team who can run a mile in 5 minutes, just hundreds if you want, to equal three or four that can do a 4-minute mile for the other side?

For these reasons, because of what I regard as a very critical need for more able people going on for higher level training, I am particularly pleased at the steps that have been taken in the last couple of years toward implementation of the report *Meeting Manpower Needs* that came out from the President's Science Advisory Committee in late 1962. These steps have included the development of a new training grant program by the National Science Foundation, a substantial expansion in the NASA trainee program, and further enlargement of the NDEA title IV actvity. At the same time I am somewhat unhappy over the fact that what we have been doing is not enough and falls below the minimum targets that were set up in 1962 by the PSAC, and particularly the targets that were set up then for engineering and the mathematical sciences.

The Nation's economy needs more able students in the engineering, mathematical and physical science areas going on for graduate work. The present bottleneck in achieving that result is lack of support for students. We have to recognize that in our present society, virtually all of the students that do graduate work in these areas expect to receive a substantial degree of financial support, of the order of tuitions and fees, plus some very austere living standard, and if they don't have that they just don't go on for graduate work.

Those of us who have worked in universities trying to develop enrollment in graduate programs find this is one of the essential facts of life. No matter how good your faculty is, no matter how attractive your activities are, if there isn't the student support, you don't get students—you don't even get bad ones.

We just need more support for people who are going on and who are qualified to work for the master's and doctor's degrees.

The fact is the National Science Foundation is spending a good deal more—I think I am right in this—upgrading high school mathematics and science teachers, than they are spending on producing new scientists and engineers with advanced training in order to be teachers and in order to serve our industrial and Government needs. I am not

objecting to the money that is going for this high school science program. It is certainly money well spent. But, on the other hand, we have another need that perhaps, if anything, is more important because it is on the cutting edge of where things affect the gross national product and our military security, and this is really being neglected in comparison. This Nation needs to invest more than it is presently investing in graduate work in the mathematical, engineering, and the physical sciences, and, particularly, in engineering and mathematics. I use the term "invest" advisedly in this connection, because money spent in giving students better training in science and technological fields relating to the needs of industries and the weapon and space programs will over the years bring a very handsome return of many kinds to our society.

This $39 billion a year expenditure for R. & L. we have just heard about by 1975, will produce more for our money, or it isn't going to cost as much to get the job done if we have better trained people working in this program. These benefits include economic returns, higher standards of living, and increased military security. One might say in a philosophical sense, transcending all of these is also the fact that better training for able people makes a contribution of the first magnitude to the quality and the humanity of our civilization.

Thank you.

Mr. DADDARIO. Thank you, Dr. Terman.

Our next participant is Dr. M. H. Trytten, Office of Scientific Personnel, National Academy of Sciences.

Dr. Trytten, we are pleased to have you here.

STATEMENT OF DR. M. H. TRYTTEN, OFFICE OF SCIENTIFIC PERSONNEL, NATIONAL ACADEMY OF SCIENCES

Dr. TRYTTEN. Coming at the end of the line here—we are well aware that Dr. Dees is coming along, but of those preceding him I come at the end of the line, and this has both its advantages and disadvantages. Sometimes you find that your speech is all shot out from under you in cases like that, and in other cases it gives you the advantage that you can potshot at what other people have said.

In my own case, I would like to make two rather brief points because the time is moving along.

The first of these relates to a thread that I think has gone through the comments here in the case of several people with regard to the need for more study in depth of the various manpower problems that we have been talking about. I suppose one might call this sort of a basic research as applied to some of the others. Our concern over the past few years has focused a good deal on getting information, factual information, and I for one would certainly like to pay tribute to the National Science Foundation for a marvelous job—marvelous improvement in the extent to which we have information on manpower in this country—but I also know in doing that, in establishing a series of that kind, one creates a tyrannical situation. These recurring series are tyrants. They determine what people are going to do today, and the next day there are deadlines all over the place, even to the extent of determining what you are going to do on the 3d of July 1966, and so on. It doesn't leave much opportunity for this kind of concern

in depth for what these statistics mean, a study of the problems in depth. It is this, I think, in which Dr. Wolfle was driving at in his testimony here about a month ago to this committee when he spoke of the need for a group or an entity, perhaps—I think he used the word "agency," I would prefer to use the words "some kind of entity" for this kind of research—of a very contemplative, analytical nature to determine the meaning and significance and completeness and relationship of all the factual information we are getting, together with factual information on the needs of society. Dr. Wolfle mentioned one such agency which has been established, and of which he is now serving as a chairman, the Commission on Human Resources. This is an outgrowth or, rather, a reestablishment of the same kind of an agency back about 15 years ago, on which he served in such a distinguished manner, and whose report was, I think, a genuine milestone in this whole area. It was the opinion that something like this was needed again that led to the reestablishment of this kind of commission.

The thing I would like to comment on, since we are talking about the NSF, is the problem of support for that kind of an agency. It is financed at the moment with private funds, and the experience of the agency, I think, is an indication of the kind of problem we have here in supporting this kind of an agency. It has what seems like a fairly generous support from two of the foundations. Nevertheless, this kind of work is expensive, and the grant itself establishes a terminal point. What is done must be done between two specific dates of fairly short duration.

About 2 years, in fact, remain during which these studies are to be carried out. I think it is obvious that this information shortens the focus that can be established for this kind of study.

There has been no thought given yet of any practical nature to finding support elsewhere. But it seems to me entirely reasonable to ask whether a perfectly satisfactory agency, such as the NSF, or indeed other agencies, should not use this kind of situation to get some of this done, to support this kind of research. I have a feeling that this kind of research should be done outside the Federal Government. I think this is a debatable point, but my feeling is that it is more likely to be done outside of the Federal Government. And I also think it is dealing with matters which are significant, which are sensitive, if you wish, with respect to the nature of our private activities in this country in training and indeed in the utilization of scientists. So I have a feeling that it is more proper to be outside than inside the Federal Government.

However, as I say, this is entirely debatable, and this is not to suggest a particular approach for this particular agency at this particular time, but merely to point to it as an example of the kind of problem that I think applies when we talk about getting this kind of research done in this country.

I would like to mention one other point, which goes back to what has been said around the table here with respect to traineeships, fellowship programs, and so on. There is, I think, a very real question which has been alluded to by one or two of the speakers as to where the most lucrative target is, if one does indeed want to expand the production of scientists and engineers, as Dr. Terman feels, and I

think the rest of us feel, is very important to do. One notes, for example, the percentage of students in the freshman year in the science fields, and for the moment let's leave out engineering, which according to Dr. Lecht is decreasing in percentage, in these other areas it remains about the same, and partly this is due to the fact that mathematics has actually increased a bit. The flow into the graduate school, however, because of the increasing amount of support, has gone up quite a bit. Much of this has been by the invention of new types of fellowships, such as traineeships, and the National Defense Education Act fellowships, and so on, in which we have, I think, inadequate information as to the quality factor. We know a good deal about the quantity, the numbers that are supported by the program, but we don't know enough about how these people compare with other people on other programs with respect to how good they are. I don't mean to say that I have any suspicion that the quality is going down or up or anywhere else, but I am trying to say that I think it is a part of prudence to try to build into these programs some ongoing measure in which we will know the kind of people we are supporting.

I think that is all, Mr. Chairman.

Mr. DADDARIO. Could you expand on that last statement just a bit. What do you mean when you say it is prudent to build a quality factor into the program?

Dr. TRYTTEN. I would not suggest that you build in any quality measures that would be used as a basis for the selection of the individuals. This is not what I had in mind so much. One turns to the institutions, themselves, and asks them to make the selection. But it would seem to me perfectly proper to request some sort of postaudit as to quality. Take some kind of test during the course of the year, perhaps a graduate records examination, or whatever it might be, so that sometime before the end of the first year's period, and possibly reflecting whether the individual has continued, or not, there be this kind of measure which is on the record, and which is reported to the donating agency.

Dr. TERMAN. May I make an additional observation on that point: I have been pressuring our own people at Stanford on the National Defense Education Act program to make an initial audit on this because we have a large Ph. D.-producing program independent of National Defense Education Act, but we have worked in National Defense Education Act people. We would like to see how well our own departments of the university have handled these Government programs in relationship to others. I think for our own self-discipline this is good. If there was some outside pressure to get an audit, also, I think this would be even better, because it would help me to get the material that I think we need for our evaluation purposes.

Dr. CRAWFORD. I agree with Dr. Terman and Dr. Trytten that this business of keeping an audit of how well you are doing is desirable. An initial audit is fine, but the use of some general applicable, well-established testing instrument is also important.

Dr. Trytten mentioned the Graduate Record Examination, and I think it is safe to say that this particular tool or testing instrument, like most of the instruments, could stand a great deal of improvement, and needs it quite badly. One element perhaps in the improvement of this

depth study of manpower, one necessary element in providing this post audit or this keeping tab, is the getting underway of a study to improve, normalize, and really evaluate such things as the Graduate Record Examination.

Dr. TRYTTEN. I would want to say amen to that.

Dr. TERMAN. I agree this would be very helpful, but I do not think we have to wait until it gets done, because we have pilot groups that are representing the people who are going through with other forms of support of the traditional type, and we can use these groups at least as some sort of standard of comparison in the meantime. So let's get on with it.

Dr. CRAWFORD. Let's get on with it, but let us sharpen the tools as we proceed.

Dr. KILLIAN. This is something that the universities have got to take the responsibility for doing, it seems to me. Any kind of national effort to impose any kind of a test here may well be a boobytrap.

Dr. TRYTTEN. This is why I said not before the selection. I think that would deny the nature of the traineeship selection program. But afterward is a different matter.

Mr. DADDARIO. Do you have further comment on that, Dr. Crawford?

Dr. CRAWFORD. No.

Mr. DADDARIO. Dr. Killian, how would you get the university to do it? I quite agree that they should, but they already have the opportunity and have not done so.

Dr. KILLIAN. I am not so sure that they are not steadily increasing their standards for graduate study. In fact, I think there has been a marked elevation of these standards in the last 5 years in this country.

I would make this general comment which has a bearing on the allocation of NSF efforts and funds. It seems to me in the long run one of our problems here is to have a pool of talent that would be sufficiently large and sufficiently good so that the graduate schools can make a better selection than they have been able to make so far. This brings me back to the point I made in my own remarks that I think the whole question of science preparation in the precollege schools, and the improvement of curriculums at the undergraduate level, is of fundamental importance in getting the kind of graduate students that we need in this country. Therefore we need very much to stress this part of the program as a long-term effort. If we delay and defer the improvement of teaching in science, we are going to delay the increase in quality at the graduate school level. I also think the better teaching of science at both the precollege school level and the undergraduate level is going to attract more first-rate students in this field in competition with other fields, and we need to do this now.

Dr. CRAWFORD. To attract more and better students into the teaching of science?

Dr. KILLIAN. That is right.

Mr. DOUGLASS. If I could just add an additional second to these points, which I feel so strongly about. We talk each year about the numbers of engineers that graduate, and no one faces the fact that these people are just like everybody else. A lot of them aren't very good engineers. A lot of salesmen are not good salesmen. The as-

sumption that the figures tell the full story is absolutely false. We have people who have tried to imply that somehow people who have come into our files must be men who are restless, they must be second rate somehow. This is not true. We have our fair share of Ph. D.'s, we have our fair share of masters, and so forth. I would say 90 percent of these people are unsuccessful through us in the average job hunt, and yet we put them right now against the needs of some 70 employers, the big ones right across the country. The ones with needs yesterday for 2,000, 4,000 engineers and scientists. And yet with these fabulous needs, the company with the size of Boeing or Douglas, taking a look at 600 engineers we brought into New York City several weeks ago, the company bids a top of 100 for interview, and maybe settles for 10. So the screening is harsh.

When they get out of college this is when their chance is best. As they get older, the world gets much more harsh. By the time they are 35, the world is hard; indeed, you cannot speak about engineers at 35 or over in terms of quantity because the quality factors become determinant.

Mr. DADDARIO. Was this what you had in mind when you referred to the possibility of retraining these men over a period of time to meet the rising needs within the community?

Mr. DOUGLASS. Yes. We have wondered, sir, how one can talk about shortages when there seems to be every year—even at the peak of the manpower rush in 1962, when NASA was out recruiting everywhere, the shortage was great, yet this same factor that I have talked about has been true, a tremendous waste of people.

Three years ago I met Dr. Pickering and Mr. Miller at a Rocket Society show in Los Angeles and we talked by an exhibit there just briefly, and I will never forget it because Dr. Pickering said he thought that perhaps 25 percent of the people they turned down at the Jet Propulsion Laboratory could probably be useful to the Jet Propulsion Laboratory with as little as 3 to 6 months of training in things that they lack. They were all right as people, nothing wrong with them as people, hirable, but on the other hand the Government doesn't underwrite education in advance of employment. So they turn them down because they are under pressure, as is every defense contractor, to do things yesterday, and they cannot afford training schools in advance of employment. Yet there is this very frustrating factor of the power engineer, for example. We had a study 2 or 3 years ago, it is again not a very deep study, but we were curious why all these people were being turned down by the glamorous companies of today; 89 percent of industrial engineers, 91 percent of civil engineers, 94 percent, I think it was, of the power engineers, the pre-1948 engineers. You can say it is an age factor, but they just don't know the right things for industry today. There is a problem here.

I think industry itself contributes to it. I was down here with the Gilliland Panel a couple of years ago, and we had the Bell Labs people here, and they told us of their fabulous continuing educational programs. The only thing they didn't really get down to, nor does anybody like that, is that this continuing education has up to now pretty well ceased at about the year of 35. The first 10 years you can go get your master's and your Ph. D. and get pay increments in the

better companies; but around 35 years of age the faucet is turned off, and technical obsolescence continues.

Dr. KILLIAN. Mr. Chairman, this just seems to me to support in the most eloquent sort of way the importance of better science education, better fundamental education, better engineering education that gets at the fundamentals. It gets rid of obsolescence, as it represents a concerted effort to be innovative and to be advanced enough and up to date. I think this is one of the major matters that we have in this whole matter of quality in graduate study at the present time.

Dr. TERMAN. To second that, but in a slightly different way, the student who goes on for a master's degree has a much better base from which to work when shifting from one area of emphasis to another as times change, and the fellow who goes on and gets a doctor's degree has even greater flexibility available to him in his career. He has learned enough different things so that he can move into new areas effectively. This is one of the very important social values of graduate education, i.e., these people can learn by themselves much better than if they have only a 4-year training.

Mr. DADDARIO. It gets back to Dr. Killian's point that if you have the solid training all the way down the line, the opportunity for obsolescence becomes less.

Dr. TERMAN. The opportunity for the person to self-remedy his deficiency is very much greater.

Mr. CONABLE. Looking at this in a little broader sense, one of the great problems of living in our society is to stay really alive, and this applies to lawyers, this applies to doctors, this applies to Congressmen. It certainly is not a peculiar problem to scientists.

I take it that you gentlemen are suggesting that with respect to science, the Government perhaps has a role that goes beyond the individual's responsibility to take care of himself. The Government has an obligation, for instance, to see to it that a man keeps himself trained in modern terms, that he keeps moving ahead in an individual sense because of his social utility, that his cutting edge does not become dulled by the processes of obsolescence.

Now, am I going too far?

Dr. TERMAN. No.

Dr. KILLIAN. May I respond to this? I would not say the Government has a responsibility to this individual man to keep him up to date. I would say that in the planning of a program for the support of education and for the support of science, it is of enormous importance that we recognize that the rate of change in the field of science and technology is so great that we have a special problem and ought to provide opportunities first of all to train people more fundamentally so that they are more versatile, and adaptable to change, and, second, to recognize that there is a problem of additional graduate study to give this higher degree of adaptability, and even a postdoctoral study, and further a postdegree education, a continuing education, which is steadily becoming an increasingly total part of our system.

Dr. CRAWFORD. I think there is an important element here when we talk about the need for retraining; the very important point that Dr. Killian made, that if a man has sufficient basic science in his original training, if he has really mastered, so to speak, Maxwell's equations

and not just network theory, then new developments in science are easier for him to keep up with. I think that is perhaps the most important point that comes out of this. I think that when we hear about these large numbers of engineers over 35 who are in need of retraining, what we are really seeing is a backlog from the period in which most of the practitioners in engineering and science had not received proper advanced work, when as some of the figures that have previously been cited show, most people took a B.S. and went out in industry.

As to whether or not the Government has an obligation to the individual, or not, I do not think it has an obligation to the individual unless you need that individual's potential contribution.

Mr. CONABLE. For a social purpose?

Dr. CRAWFORD. For a social purpose.

Mr. DADDARIO. Mr. Conable has raised the point that not only scientists become obsolescent, but also Congressmen. We have a member of this committee who is both a scientist and a Congressman.

Mr. Vivian, would you care to comment?

Mr. VIVIAN. I am afraid, as a scientist, I have become very obsolescent by now.

I have a question on a somewhat broader scope than the comments so far.

Most of my friends and colleagues in the scientific professions at about age 35 when their families have formed, realize that life has two ends, really an end and a beginning. They begin to make different decisions than they made before, and it is a time when they realize that their background training is not very satisfactory. In a sense it is the time for another new career for them. Again, around age 55 a great many men realize that what they have hoped for in life, and what life really offers, have become somewhat separated. For some it is a time to plan what other job they can get, if they can get a job at all. It is another critical stage.

I would also point out that a number of industries in my area are now giving retirement training courses at about that age bracket, and these courses have been very, very happily accepted. They are apparently one of the few things that everyone involved seems to agree is beneficial. I refer now to the company, the universities which are backing them, and I think very wisely, and the individuals.

I would like now to drop back to another critical age, that is, about age 15. This is the time in high school when a competence in individual careers is beginning to be formed for a person who does not go beyond high school, who does not enter college training. We give our entire population between ages 15 and 18 a free education to meet the needs of the age span from, say, 18 to 35. We pay for the education out of public funds as a worthwhile investment.

I propose now that we consider the following: From age 35 to 38 we give free public education to everyone who wishes it, including some provision for family support for a period of 3 years. This is a retraining phase in whatever occupation a person may select. From age 55 to 58 we do exactly the same thing, and we drop this sacred cow that one can be trained at public expense only up to age 18. I suggest this for consideration by the panel.

Mr. DADDARIO. Mr. Douglass?

Mr. DOUGLASS. I think this point is germane——

Mr. DADDARIO. I am not asking you necessarily to reply.

Mr. DOUGLASS. That is all right. I wanted to take Mr. Conable's observation first. They are both in the same area.

The Government certainly doesn't want to get obligated for everything that it is not already obligated for. It is probably obligated enough.

On this question of retraining, I think it is worth while to remind you all, and for us to remind each other, that the Government is paying the bill on the major part of this problem anyway. If Dr. Pickering is right, the retraining cost would probably be less than hiring an engineer from somewhere else.

Mr. DADDARIO. Or cancel a program because we do not have the people to do it.

Mr. DOUGLASS. That is right. I think it is very important to remember that the bill is probably being paid in 80 percent of the cases by the Government, so inefficiency in scientific and engineering manpower is a Government bill.

The question is not whether or not the Government should be responsible in this area. We are a little bit past that, as long as the Government is as heavily in research and development.

As to retraining at 30 or 33 or 35 I might throw out how simple we thought this might be effectual. This was just a quick suggestion at an exhibit at a show. The idea was maybe that there could be sort of a review board at Pasadena and JPL would meet this man and say "This man is hireable to us. We would like his record. We see the things he doesn't have that maybe he needs here". And they would send him with a little ticket down to a review board, so to speak, and this review board would say "Yes, indeed, you can get these courses in the Los Angeles area." After he had successfully completed these courses he would report back to JPL. In this area there are many problems. That sounds very simple, but it is still perhaps an approach. It is the type of thing that I mentioned much earlier, the possibility of demonstration projects to at least find out if some of these things lead to solutions to problems that have existed for years.

Mr. DADDARIO. Dr. Dees?

STATEMENT OF DR. BOWEN C. DEES, NATIONAL SCIENCE FOUNDATION

Dr. DEES. Mr. Chairman, at some point I would like to have a chance to make some comments. I am not terribly sure this is the point at which I should come in. I did, however, want to pick up this last comment with respect to demonstration projects of various kinds. Perhaps I could start off by saying that NSF has in fact in this and many other areas attempted to try out this, that, or the other way of coming at some of these problems.

It is perfectly true, I think, that one can say in this as in most other areas, that all we really need in order to do most of the things that have been recommended here today is more money. The fact of the matter is you cannot do these things without the dollars to back the play.

I would like, if I may, Mr. Chairman, to go back a bit and pick up some of these things because it does turn out that on the review of what I have been hearing this morning there are a number of points that NSF does necessarily get involved in, in one way or the other. Fortunately, in part because he is a member of the senior group advising the Foundation on such matters, Dr. Crawford is in a good position to do something about his suggestions, so I am not going to spend very much time on this except to say that with respect to his last suggestion on the business of individuals doing some teaching while on fellowship tenure, I think he will agree that this is a question which has been given a great deal of thought and concern. There are not really any easy answers as to how exactly one should go about this, for the simple fact is that what holds for geology and oceanography does not hold for mathematics; what holds for chemistry does not hold for psychology, and what holds at institution X may or may not hold at Y, but it surely does not hold at Z.

In the national programs that we must concern ourselves with, you have to write rules, regulations, general guidelines that are nationally applicable. This is where one really runs across some very difficult questions when it comes to anything that is mandatory, and I think Dr. Crawford was quite wise in saying that this thing should not or could not be mandatory. So much for that one point.

In connection with the general question and the one that you led off with, Mr. Chairman, concerning the statistical picture in the United States on manpower in these areas, I personally have been wearing a hair shirt on this particular problem for a number of years. Here the question has been, and remains, why doesn't NSF do this? Why doesn't it do that? We occasionally encounter—as for example among the group assembled here this morning—some people who really know the situation who will say NSF has been doing a lot, and that what it has done is justifiable.

The question that really is at issue here has been put before you by both Dr. Wolfle and Dr. Brooks earlier, and that is this: there is an absolutely insatiable desire on the part of those who are interested in information. No matter how much you get, there is always a great deal more that is wanted. This is not to say, and I want to emphasize this strongly, that we feel we have done all we should have done, or all that we perhaps could have done in terms of the resources available to us. But in connection with one of the colloquies here earlier, a question was raised as to the attitude toward the appropriations that the Foundation has had in this general area, and I quote to you a sentence or two from an appropriations report for several years back.

> The budget estimate includes $800,000 for making national science policy studies. The committee reduced the item by $50,000, which is indeed a very small amount, and it will expect the agency to greatly reduce this item next year. Many of these studies are of doubtful value and should be curtailed.

This is not a unique statement, and it is the kind of thing that we have to work with and around and try to sell our product better as time goes on.

I personally feel we at NSF have done a relatively poor job of selling the need for this kind of information, despite the fact that we know it, and the fact that many people who want this kind of information come beating on our doors day by day. But it isn't

necessarily the same thing to know that something should be done and to have the resources to do it.

Mr. DADDARIO. Dr. Dees, I would like to make a comment in that regard. I think the importance of the discussion we are having in hearings relate themselves to bringing to the attention of the other committees of the Congress the facts surrounding the needs on such a subject. We would hope that when these hearings are finished that we can come to some determination as to the importance of having the kind of information which you are talking about, which has received that negative kind of assistance in the past. Dr. Killian has referred to this in his remarks as being so important that it should be under a single agency, and with the National Science Foundation having an important partnership role, if not being the only agency involved. I think the important thing is not to say that the National Science Foundation has not done what it should have done, but recognizing that it does have a limited appropriation, to find out the reasons why it has not and to see what can be done to increase support where necessary.

Dr. DEES. Please don't misunderstand me, Mr. Chairman. I am perfectly, at least I hope I am, aware of the general attitude in this room on these matters. My point was simply to make the point for the record that in the past it is true that we have known what should have been done, we have wanted to do it. We have not always been able to get the resources to move ahead on these things as fast as we felt we should. This is highly correlated with a number of the points that have been made by those who have been discussing this particular issue this morning.

Mr. Douglass, as he points out, was present before the entire committee of this same name some years ago in connection with these matters. He made a number of points, all of which I think we would have wanted to agree with or disagree with in detail, but in terms of the general thrust there was certainly no quarrel, but the fact of the matter is, as Dr. Trytten has pointed out, there are certain things that you must do in order to have a basic background of information. By the time we have done that amount, plus the kinds of things that have to be done in responding to special requests from groups such as the President's Science Advisory Committee, and so forth, it is frequently so that our overtime bill has already run up to a point where we simply cannot work people any more, and the problem, therefore, is a very acute one.

Now, I wanted to make a few, and I hope somewhat more substantive, comments with respect to several of the points that have been made. We are doing a great many things, even despite this rather dismal story I have just been telling, which are at least relevant to the basic issues that have been put before you this morning. Let us take, for example, the one that was raised concerning the percentage of all degrees—the percentage of engineering degrees as a percent of all degrees. I am still not saying this right.

At any rate, the fact is we do know something about this, and we have been funding a group within the engineering fraternity made up largely of operations research specialists to try to get to the root of these problems. We also for years in fact have been supporting,

as much as we could, work on the general question of motivation, the identification of creative scientific talent, and so forth.

I could have brought, and you see with me a 2-inch stack, something of the order of a 2-foot stack of reports that have resulted either from our own direct work in such areas, or the work that has been carried out under the auspices of the Foundation by grantees or by contractors.

I think I would only wind up, Mr. Chairman, by making one point straight for the record in connection with a point that Dr. Terman made. The expenditures by the Foundation in the general area of what we call supplementary training for teachers are about the same this year as those which we will make for support of graduate students. In 1967 we will be spending even more on the direct support of graduate students in this area. If one takes into account the support of graduate students through research grants also, I think it is probably so that we have been in the same ball park in these two areas for a long time.

On the other hand, I think, with Dr. Killian, that it is necessary to look at the timespan that one is talking about in trying to assess the appropriate distribution of funds as contrasted with the long-range future when one is trying to do something about upgrading quality over a long period, and the business of getting more out of a given crop of college graduates into graduate school where we all know, without any debate, that if you go too far you will have to dip too far down into the barrel in terms of quality. So the question that we have always faced in this connection has been this very difficult subjective judgment as to what makes sense over time, not what makes sense this year or next year, but what should we do in order to make sure that 20 years from now the United States is as well off as it possibly can be, given the kinds of resources now available in these areas.

Thank you, Mr. Chairman.

Dr. KILLIAN. Mr. Chairman, may I say I think this long-term problem is probably the most acute problem that we are addressing ourselves to today. The fact that we didn't 10 or 15 years ago get started in creating additional centers of strength in this country is going to be a real handicap down the road. If we don't now do something to continue this process of strengthening fundamental education we are going to suffer from it 10, 15, or 20 years from now.

Mr. DADDARIO. Dr. Killian, you touched on the point of creating more centers of excellence. This is really not a question of geographical distribution. I wonder if you would expand on that.

Dr. KILLIAN. I would simply elaborate on that that I think it takes such a long time and so much effort to create these kinds of centers that we have got to find those that have the greatest potential right now and move ahead and give them support wherever they may be if we are going to increase our capacity in the shortest possible time.

I fully agree in the long run it is terribly important that we get a fuller geographical distribution of the centers than we now have, because we need to have more centers of strength accessible to other parts of the country where they are not accessible now.

Mr. MOSHER. Is it easy to measure the potential? Is there a generally understood criterion to determine this potential?

Dr. KILLIAN. This is a very difficult and in many ways a kind of subjective process. But I would say every agency, every agency granting funds, whether to industry or Government or a private foundation, has to make this judgment as to what is good, what is promising, what has the greatest potential. I don't think we should back away from it, and I think it can be done with reasonable action.

Mr. MOSHER. The motivation, the climate of desire?

Dr. KILLIAN. Yes, sir.

Dr. CRAWFORD. It is at least as easy to do as to identify the promising graduate students from those who will not turn out so well in graduate work. It does involve subjective judgments, as Dr. Killian has said, but it is the sort of judgment that can be done. It is tricky, but it can be done, yes.

Mr. DADDARIO. Dr. Terman.

Dr. TERMAN. This matter of centers of excellence is really important, because if you just look at the flow of people coming through our colleges, beginning now, and those who will be getting on to graduate schools, there isn't the capacity in the existing strong graduate schools to take care of the needs, and no reasonable expansion of those will do the job. So you have to have more centers of excellence and, of course, this is going to react back down through the undergraduate program as well.

The Seaborg Committee issued a report on November 15, 1960, nearly 5 years ago which says "Additional centers of excellence are needed." Again the Gilliland Panel report in 1962 says the same thing. As time passes the urgency becomes greater because the emergence of new centers hasn't kept up with the growth of the college population in recent years.

Someone asked the question about geographical distribution, how do you identify it, and so on. Well, I have been involved with a new center of excellence for though it may be hard for people to believe it now, Stanford was an underprivileged institution as of 1945. This is the place where I have lived most of my life, and I have seen it emerge. These are things that you don't do overnight. You don't create a great center in 1 or 2 or 3 years. You build and you strengthen and you build some more on the last successes, and gradually you emerge. It takes a lot of effort, exerted over a long period of time, and it takes leadership. The quality of an educational program is only—this is perhaps an oversimplification—is only loosely connected with the dollars that you pour into it beyond a certain minimum of dollars. An awful lot is determined by how much you get for the dollars you are putting in, whether you get a lot or a minimum amount. This is a very important factor.

I think also the geographical distribution will almost automatically take care of itself if we get more of these centers. If we have 30 really top centers in engineering and science, as against 15, or if we get 50 instead of 25, the additional ones are going to be inevitably spread. You are not going to start another one in Boston or on the San Francisco peninsula or in Pasadena. They are going to be in different locations obviously. So you almost get an automatic dispersal.

Mr. DADDARIO. I do not recall exactly how you phrased it, but you said something about the fact that student support is somewhat equally

attractive as the quality of education they might get at one place or another. How do you fit that into this whole process of growth?

Dr. TERMAN. Well, you cannot get first-class students to go to a place if there isn't the means for them to live after they come there as students. I am talking about the graduate level. At the undergraduate level the tradition is for the families one way or the other make major sacrifices to support the youngsters.

Dr. KILLIAN. This varies by fields.

Dr. TERMAN. Yes. I am talking about the science and engineering areas. In law there is a theory that if the youngster gets into law, he might make money, and the family will try hard to provide support. The same is true in the graduate schools of business and medicine, but to a less extent now than at an earlier generation.

You can have a fine faculty, and so on, but if you don't organize the finances to support the students, then you find it isn't practical for them to go to your school for their advanced training in science and engineering, and they go elsewhere where the support is available.

We see this in our university. The departments that organize their financial aid program will get the students, and the departments that are equally good as far as the stature of its faculty, and so on, and don't do a good job in providing financial support don't get them. Students apply and then don't come because they have financial problems that aren't being solved.

Mr. DADDARIO. Mr. Roush.

Mr. ROUSH. Mr. Chairman, it seems to me that the potential for these centers of excellence already has a pretty fair geographical distribution with the possible exception of certain areas of the South where I think some work has to be done. It seems to me also that in developing these potential centers of excellence we are going to do more than just develop that particular institution. It will tend to upgrade other institutions in the area which themselves may become potential centers of excellence. I know in my own State, Indiana, that the excitement which comes from the activities on the campus of Purdue has an effect on the programs of Indiana University and Notre Dame University, and vice versa. It seems to me that this will be one of the things which will come from this attempt to develop these centers of excellence. I would hope that the program could be accelerated in order that we might have this geographical spread of activity throughout the country.

Thank you, Mr. Chairman.

Mr. DOUGLASS. Mr. Chairman, this is a heavyweight panel, and I am painfully conscious as we are introduced that I am the only person who isn't a Ph. D.

Mr. DADDARIO. You have plenty of company.

Mr. DOUGLASS. At this point I just would like to say something that I think is terribly important, and we might forget it in all this talk of fellowships. There is a disastrous fact of life that even people who go to 4-year colleges perhaps should have left after a couple of years. There is a fad which brings lots of mail to my office—parents who are disappointed that their son dropped out of college. I don't think that they realize, many of them, that the colleges count on the dropouts. They wouldn't have room if everybody stayed.

Dr. KILLIAN. But they don't count on them.

Mr. DOUGLASS. It is a statistical fact of life that people do drop out, and it is an added fact of life that people should not be second-class citizens if they have a 2-year college education. There should be some concentration of pride at each of these levels. You need the excellence in the 2-year man. As a matter of fact, the excellent 2-year man can make the excellent 6-year man look better if there is a good working arrangement between the 2-year man and the Ph. D.

Dr. CRAWFORD. I just want to bring out, Mr. Chairman, in your inquiry about the attraction of fellowship support for students, a note I would like to underscore, if I heard it correctly, a note of concern for the student. It is true, I think, that you can run into a danger in this center of excellence buildup if you desire to establish and upgrade existing institutions; you can run into a danger by providing an institution with fellowships before it has a really adequate graduate program to offer the student. This can be a very real thing. There is a process in building up a graduate program which involves money and time—quite a lot of time, quite a lot of money, for that matter—and it involves a concern and an integrity and a leadership on the part of the institutions' administration. That process involves first recruiting some good faculty members so there is a program of at least the minimum integrity, minimum quality. There is help available for institutions that want it. The Council of Graduate Schools has a much-used consultation service for institutions who are seeking to improve their graduate program. They get very hard-hitting and informed advice and counsel, from this independent group, the Council of Graduate Schools. At some point in the build-up you have an institution where, although you cannot offer the graduate student quite the education that he would receive at Stanford, he can receive a graduate education that would be beneficial to him. At that point the institution really needs fellowship support so it can begin to attract graduate students, because once you begin to attract graduate students this aids in building up the faculty. You have kind of a circle, if you will, that has to be broken into at some point and then rolled around to build up into a center of excellence.

Mr. DADDARIO. I have a question which I would like to direct to Dr. Killian, but it does not necessarily exclude anyone else. It goes back to this question of information.

In regard to the study made by the Committee on Manpower Utilization, you talked about the need for having a single agency with the authority to coordinate manpower information. I am not necessarily suggesting that NSF do this, but I thought it would be helpful if you could develop that line of thought further.

Dr. KILLIAN. May I refer to the specific recommendation that was made by the National Academy Committee on Manpower Utilization, of which I was Chairman, on this point. Its recommendation was that:

Responsibility should be assigned to a unit within the Executive Office of the President for (*a*) stimulating and coordinating planning by Federal departments and agencies with respect to scientific and engineering manpower, (*b*) promoting research both inside and outside Government that is likely to facilitate such planning, and (*c*) taking the lead in developing an integrated program for the continuing collection and analysis of information relative to operating and policy persons on scientific management and manpower. While the com-

mittee does not recommend a specific location for this unit in the Executive Office, it notes the feasibility of placing it in the Office of Science and Technology.

That was a carefully considered recommendation of this committee at that time, but I would emphasize the fact that it did not want to designate a specific location beyond suggesting this as a possibility. It would seem that if this coordination and collection and evaluation feeds into the planning process, it must be so located that it can be related to places where decisions are made.

Is this responsive to your question?

Mr. DADDARIO. Yes, it is. I am just thinking about how it relates to accomplishing these other objectives. What are the levels of technical competence of which we are capable, and how do we achieve the goals that Dr. Lecht has referred to for the years ahead. How important is it that we accomplish this, and accomplish it quickly so that these projections can be more meaningful than they now are.

Dr. KILLIAN. My response to that was if we had available a group, even an individual, but a group particularly which was concerned with this problem, which could be instigators and stimulator of the kinds of things that need to be done, both in the private sector and particularly in Government, that this would help us make headway.

I don't see that we have that single place at the present time, to initiate and instigate and to stir up. This is not a criticism of the National Science Foundation. I agree that it has done a superb job, but the problem is much broader than the NSF area of activity.

Dr. DEES. Mr. Chairman, may I make a comment on this, because it is I think important that we at least not fail to say what exists at present.

Several months before Dr. Killian's group published what is now known as the Killian report, a recommendation was presented to the Director of NSF that there be established in the National Science Foundation, correlative with the office which is responsible for the mass data collection of information of the sort that we have here, a group that would concern itself primarily with science resources in the country generally, including but not limiting itself to the area of manpower.

This group has now been established. It has been in being for just over a year. We are beginning to make some progress with respect to the kinds of things that were recommended in the Killian report.

We are not claiming that this is the answer to the various questions that were put there and the problems that were brought out there. We do feel that many of the kinds of difficulties that existed before when we had no explicit staff arm working on this kind of problem can now be at least ameliorated. The group is a small group. It will this year have only about a half million dollars for outside grants and contracts. But this in itself does represent a major step so far as NSF is concerned in the direction of trying to make sure that depth analysis that will penetrate more deeply than we can do in the objective factfinding studies will in fact become possible.

Dr. KILLIAN. May I make one further comment, that the Executive order establishing the President's Committee on Manpower—it is a Cabinet committee—clearly had among the responsibilities of that Cabinet committee this general domain, and I would judge that the

Cabinet committee is considering ways and means of setting up this more centralized evaluation.

Mr. DADDARIO. Are there any other comments?

Mr. Vivian.

Mr. VIVIAN. I have a series of questions, Mr. Chairman.

First of all I would like to endorse the remarks made earlier by Dr. Terman, that it is virtually impossible to have a graduate program in the sciences unless there is additional support for students to live. With the age where people marry into the less-than-28 bracket, this will become a continuing problem.

I remember my days at MIT well enough to know that most of my compatriots at graduate school were supported by the mission agencies. Without that support, I think the graduate school would have been half its size. I think the same is true of Stanford. I believe the NSF has played a totally insignificant role.

Dr. TERMAN. Until recently.

Dr. KILLIAN. It has set a standard that is enormously important to every other agency in the Government.

Dr. CRAWFORD. I think it is relevant to say that the NSF fellowship program and the program for support of graduate students has been the best administered and has been the model.

Dr. KILLIAN. That is what the dean of our graduate school said.

Mr. VIVIAN. All the major centers of scientific excellence have been heavily supported by the mission-oriented agencies, especially DOD. Irrespective of whether this is good or bad, I think it is largely true. NSF is playing a larger role today, which I am glad to see. I am in favor of that. However, my remembrance of NSF's fellowships is that by the time my family had one or two children, which is not the exception but the rule, I could no longer live on an NSF fellowship. I would have had to subsidize my income by other methods. As a consequence it was easier for me in many cases to work part time or full time as a practicing engineer or researcher, and to continue my education on a part-time basis.

Therefore, I have some doubt as to whether the NSF fellowships satisfy the needs. On a competitive basis I think it can be pointed out that many people do not take them, not because they would not be accepted, but simply because they could not live on them.

Dr. TERMAN. There was a revision of the stipends upward about 2 years ago that has made a major difference. It used to be a quality program that was underfinanced. This has not been completely cured but it has been enormously improved.

Mr. VIVIAN. I am glad to hear that, and I apologize for being out of date.

Dr. KILLIAN. Plus availability of sufficient loan funds.

Dr. TRYTTEN. Plus the availability of a remunerative employment for the wives of graduate students.

Dr. KILLIAN. We try to provide employment for as many of the wives as we can that want it.

Mr. VIVIAN. That is an interesting step since I was there. My wife went to Boston University. I have covered that subject sufficiently. I am glad that it has improved.

I would like to go on to the subject of the $39 billion 4 percent figures that were quoted awhile back. I have used these figures in

a speech and therefore I hope they are right. However, I have a suspicion that they were based on a projection which all of us would find difficult to substantiate if one with a sharp ax were to go after it. I am sure that is a situation you can do nothing about. It is impossible to give an accurate prediction. I have been fascinated to find a gross absence of what we call adequate mathematical models of the economy sufficient to support my own actions in Congress. Therefore, I ask what you use as a model for predictions over the years. The amount of money which would be spent by NSF should be based to the extent possible on a competent econometric model. Do you feel you have an excellent model to predict the $39 billion and 4 percent?

Dr. LECHT. The National Planning Association over the years has developed a consistent detailed model of the economy, including all the major components, and we use this model for projecting purposes. It takes into account recent trends in imports and exports and productivity changes by industry, labor force participation rates, and changes in the location of industry. The projections of the trillion dollar GNP are based partially on this model, partially on tendencies in the years before making this study in the early sixties. They are also based on the fact that, according to President Kennedy at about this time, an annual growth rate of about 4 percent was a feasible target.

This, according to the President and the Council of Economic Advisers, was what the country could be reasonably expected to achieve.

Mr. VIVIAN. Let me shift to NSF. What models do you use when you depict the need for scientists and engineers?

Dr. DEES. Basically the Bureau of Labor Statistics, which has done the major studies that we have funded in this connection, have used trend lines but based on the disaggregation from all scientists down to and including the kinds of things that one can dig out of the available statistics on trends by industry, trends within Government, trends within the universities and colleges, et cetera. We are at the present time trying to develop growth models in two general areas, one at the university level, being done at Michigan State University, and one, which we still are frankly searching for some people to work on, which will have to do with the general area of the interaction between, let us say, investment in the centers of excellence programs and what will happen 5 years from now in terms of needs for more project grant money, what will happen when we and others put *x* millions of dollars this year into new graduate laboratories in terms of the needs for graduate student support 5 years from now, et cetera.

Mr. VIVIAN. I personally think there is much more work left to be done. There were remarks made earlier as to the number of graduates dropping from 10 to 7½ percent, the question is, is this significant?

In other words, how do you measure the significance of this set of numbers against the models you have? To what extent do you feel the models are adequate?

Dr. DEES. My own judgment with respect to this, Mr. Vivian, at this point in time is that we don't have enough experience with anything that is or could be called a sophisticated model to have any real judgment to make on that particular question.

We feel that it is clearly desirable to get some experience with this sort of thing, and then by retrospective looks after we have made some

judgments and some statements that planning can be based on, one can begin to make some further decisions on whether these are useful.

But I think that one of the things that needs to be remembered in connection with most of these projections is that by their very nature they tend to be self-defeating. If one comes up with a projection that there will be an oversupply 10 years from now of *x*, this in itself will see to it very nearly that there will be a shortage 10 years from now or conversely.

Mr. VIVIAN. One of the studies indicated that the requirements for industry would greatly exceed the needs for Government. It is hard to prove that today, because I believe something like three-quarters of all the R. & D. funds are Government funds.

Dr. LECHT. We were talking about the source of employment, irrespective of who financed the research.

Mr. DADDARIO. I think Dr. Trytten has a comment to make.

Dr. TRYTTEN. The only point I wanted to make is with regard to what Dr. Dees has said. I think there is a great deal of lag here between the kind of information he suggested and the effect on whether people do or do not decide to go into a field of study. The decision is based on a great many other things than their projection of what the job market is going to be at any particular time. It depends on what kind of home influences they will have, what their personal interest is, and a good many things. Wouldn't you agree?

Dr. KILLIAN. And what the impacts of their teachers are.

Dr. CRAWFORD. That is an awfully complex bunch of factors that influence this vocational choice or educational choice.

Dr. TRYTTEN. Over the period of time these transient balances of supply and demand are less and less sufficient.

Dr. CRAWFORD. You can gather statistics, and this is very, very fine, but first you have to make sure that the statistics mean something, that they weren't just filled in by the village postmaster, as the old saw goes, writing down what he pleased—you have to go back and ask whether a sensible question was asked. Does it make sense to ask a graduate dean how many students *will* get their Ph. D. *during the coming year?* We get this every year.

Having the statistics, then you have to do the interpretation. This takes a lot of time. It does take support. We mentioned the Graduate Record Examination as a useful tool. Everyone knows it should be improved. The Council of Graduate Schools would like to improve it. It costs money.

Mr. VIVIAN. I happen to agree that the graduate records examination is very important.

Mr. DOUGLASS. Here is one of the things that you must concentrate on in this whole series of statistics, I don't know that any industry depends for its planning on 2- or 3-year-old information. In the construction industry, F. W. Dodge gives daily reports throughout the country. In this manpower business, any prediction that is made today can be changed by the events of tomorrow.

Dr. LECHT. Mr. Vivian raised the question of the decline in engineering degrees as a percentage of bachelor's degrees. This is historical data published by the National Science Foundation in one of their very new and excellent sources, *Scientific and Technical Manpower Resources.*

Mr. VIVIAN. I am concerned with your predictions for the future and how significant they are in terms of how much money we put into it. My feeling is that the models we are using to predict what is going to happen 5 or 10 years from now are exceedingly inaccurate.

Dr. LECHT. I think there may be another problem, and that is the problem of what these numbers are. I personally much prefer the term "projections" to "predictions." Our ability to predict the future 10 years from now in these areas is poor indeed. I should add that "prediction is not the purpose of the estimates.

Mr. VIVIAN. Could you predict within plus or minus 3 or 4 percent in these areas?

Dr. LECHT. These numbers indicate possible alternatives for policy and the expected consequences of pursuing them.

Mr. VIVIAN. The budgets of the mission-oriented agencies, such as DOD and NASA, have pretty well leveled off, yet the image of the age is that we are going to be a science-dominated nation over the next 10 or 15 years.

Now if we take both curves—the funding of these major agencies and the prediction of the Nation's economy—somewhere in between there is an enormous gap, and it isn't just 1 or 2 percent.

Dr. LECHT. In that particular area, I suspect one of the areas of gap in that $39 billion is the role of R. & D. financed by industry out of its own funds.

Mr. VIVIAN. This is estimated as being $4 or $5 billion, and that has flattened out more than the other two. I am going by NSF statistics. I hope they are right.

Mr. DADDARIO. I think Dr. Lecht indicated an increase in research in many areas where very little is being done now.

I imagine your projection shows that these will be important national goals. Certainly there are indications at the moment that we will become more involved with problems of pollution and transportation. These programs will be very large.

Dr. LECHT. Yes. And there again this is not a prediction. I don't think anyone in the world knows how much we will be spending on R. & D. in 1975. What we have attempted to do is take the current programs which are under discussion as areas of need, and as far as we were able, either through Government studies, or studies of the National Academy, or private experts, we have attempted to estimate their cost now and 10 years from now. Summing up all of these areas including the R. & D. for defense and space, we come out with this figure of $39 billion for R. & D. expenditures in 1975.

Now whether we will achieve these needs is a question which would be difficult to answer until we are much closer to 1975.

Mr. DADDARIO. Dr. Dees, I thought you had an area of disagreement with Mr. Vivian. If you do, I would like to hear you.

Dr. DEES. I wasn't sure what he was speaking of when he spoke of this 3 or 4 percent. Maybe you were speaking of the 3 or 4 percent of the GNP.

Mr. DADDARIO. He was referring to the 3 to 4 percent that Dr. Lecht mentioned.

Dr. DEES. I misunderstood perhaps what you were speaking of, but I thought you were saying that we would be unable in any one of these

areas, let's say in the production of Ph. D.'s, to predict within 3 or 4 percent.

I would say that we are probably in no position to predict—predict as contrasted with project—closer than to 25 to 50 percent. What will happen and what we will say will happen the day after tomorrow or sometime soon is likely to be off by far more than 3 or 4 percent.

Mr. DADDARIO. Mr. Vivian, I believe Mr. Douglass has some comments on your last remarks.

Mr. DOUGLASS. I think the Congressman on the subject of models has been beating a bit of a dead horse. I think the panels have been open in admitting that the models aren't that great. It is much easier to predict soap sales because you look at the population, you know they are going to be born and they are going to need soap. But when it comes to the manpower subject, no one who publishes a study is particularly happy about it.

Dr. Killian was in the process of writing a report in 1963 when the whole demand changed completely. All the models were thrown out. No one had seen the possibility of what happened then. So the need for a new model, I think, is obvious, and the cost of it, as Dr. Dees says, is going to be great if it is going to be done. It is going to be great because it is a very complicated business.

On the other hand, I think it is worth looking into because there is also a tremendous amount of money spent (a great deal more than it would cost to find out about this market), based on assumption, opinion, and lack of adequate information, so I hope it will be looked into.

Dr. DEES. May I add to one point that Dr. Lecht made, the fact his own organization—I realize he is speaking as Lecht rather than the National Planning Association this morning—has just published a rather interesting report on the feasibility of projecting national budgets, Federal budgets——

Dr. KILLIAN. National goals.

Dr. DEES. This was, I think, a little different, Dr. Killian.

Dr. KILLIAN. I am corrected.

Dr. DEES. It actually has to do with whether it is possible to make some kind of stab at guessing what the President will ask for in the future. This is highly relevant to the question that was raised a few moments ago by Congressman Vivian, because until one is able to make some kind of guess on that point, it becomes extremely difficult to make any kind of guesses on the subsidiary matters which obviously depend tightly and couple very, very closely to this number.

Dr. TRYTTEN. If you find out how to do that, the President is going to find out about it and adjust his tactics.

Dr. CRAWFORD. I think it is probably relevant to say that I, like most graduate deans, have significant interaction with the NSF, calling on them for statistics and help in making my own projections, and it certainly is true, I believe, that in Dr. Dees' group they not only collect statistics and try to fit models to them, but that they are constantly seeking to improve these models.

It isn't a matter of getting the right model; it is a matter of hopefully improving your approximation with increasing experience. But there is a long way to go before that model is as accurate, say, as the models that we can use in the physical sciences or even the biological sciences.

Dr. LECHT. In this connection, Dr. Terman and several other people have pointed out a very important problem for research; that is, the relationship of R. & D. and economic growth. We have subjective judgments and qualitative studies which indicate that economic growth is substantially influenced by R. & D. But so far we have little quantitative evidence of what the implications are of increasing R. & D. expenditures. Some of the CED economists made estimates of this influence a few years ago, and one or two others have been working in this area.

What we could do in terms of projecting either R. & D., or economic growth, or manpower demands, would be significantly improved if we knew more about how R. & D. affected the processes of economic growth, either on a nationwide basis or regionally.

Dr. KILLIAN. Is this not also true of the effect of education on economic growth, which is an area that is just beginning to be explored?

And may I make one comment here, that I would make a projection that the enormous impact of what is happening in the field of education today through the Elementary and Secondary School Act and the other things that Congress is doing or considering may profoundly affect this whole manpower picture, particularly the demand for teachers.

Dr. CRAWFORD. We hope it will.

Mr. DADDARIO. Mr. Brown, did you have a comment?

Mr. BROWN. I will try to be brief.

Throughout our discussion here this morning, we have been talking about scientific and engineering manpower, and in previous sessions of this hearing I have been concerned about just what the experts mean when they say scientific and engineering manpower, the theme being I think that in practically all cases we are talking about the physical scientists and engineers.

I would like to raise this question and ask for an indication. Do any of you gentlemen in any of your remarks here intend any other significance or meaning than physical scientists and engineers in what you have said? In other words, is this not what we are talking about? If any of you differ from that, I would like to know about it.

Dr. KILLIAN. Mathematicians and teachers.

Dr. TRYTTEN. And the biological sciences.

Dr. CRAWFORD. I would like to include even some of the harder social sciences although I think that Dr. Terman was right when he pointed out that the greatest shortages are in the physical sciences, mathematics, physics, engineering, and so forth.

I think the biological sciences are probably the most exciting area of intellectual activity at the present time, and I think as we want to exploit the tremendous discoveries that are being made in biology, we are going to want to do something about basic biological sciences.

We were speaking about the need for sophisticated models in econometrics and sociometrics and converting guesses into predictions. Certainly this is an area that is important. I would say that the sharpest need is in the area of the physical sciences, but I would not myself by any means want to rule out the other sciences.

Dr. KILLIAN. But you include the biological sciences in the physical sciences?

Dr. CRAWFORD. No, I was making a separation.

Dr. KILLIAN. The need of the same sort exists in the life sciences.

Dr. DEES. I just want to say with respect to the statistical base which we have had threading through all this discussion it is true as of this instant that some of our studies have not included the social sciences partly because it is so very difficult to get a definition that makes sense. Here I refer in particular to the question of social scientists employed by industry, where the distinction between an economist and a market analyst or a person who is concerned with advertising techniques is extremely difficult to draw. We have thus far found that the industrial groups that we consult with have said they simply cannot give us these data.

However, other than that, all of the data that we secure on scientific and technical manpower resources include conceptually the social sciences, and we are trying to move to a point where this will be included uniformly across the board.

Dr. CRAWFORD. I would like to just include one mention also. You were speaking about going out from the physical sciences through some of the social sciences. While I don't believe there is anything like the shortage or the great demand in the fields of the humanities, yet when Dr. Killian speaks of the need for good teaching of science, this is very, very true: you cannot educate a good scientist by teaching him only science. We shall also need teachers and good teachers in such fields as history, English, the classics, and the humanities in general.

Dr. TERMAN. I would like to come back to the biological sciences and life sciences. We have to a certain extent skirted those because this area is in pretty good shape relatively speaking.

The National Institutes of Health at the time of the Gilliland committee 3 years ago was putting in something like $120 million a year into training new research people for that field. I suppose today it is $150 million. This field is so much better financed in terms of developing the manpower that is needed in the field as compared with the engineering, mathematical and physical sciences or the social sciences that manpower for the health field is not the burning problem that these other areas are.

This is important. After all, health is very important, and this is an area also where enormous advances have been made in recent years and will continue to be made. But there is a better organized manpower program there, better keyed in with the total needs, and better financed in relationship to those needs than in other areas.

Dr. CRAWFORD. I differ with you a little bit. I guess it is better financed, but I don't think it is better organized. I would make some criticisms of the way in which some of those fellowships, traineeships, research support programs, and professional programs are organized.

Dr. TERMAN. Perhaps, but I think part of the criticism is they have been pretty wealthy and have not had to operate on a shoestring.

Mr. BROWN. How does this apply to the supply of personnel in the practice of medicine and in the related health professions? I understand they are in very short supply.

Dr. TERMAN. I am speaking of the scientific activity in the biological and life sciences. These are the people who are generating new

knowledge. Of the money that I am speaking of—none is available legally to go to training medical practitioners, and there is certainly a real shortage of practicing doctors at all levels.

Mr. BROWN. I think this problem needs to be analyzed. Why do we have a surplus of funds for the training of researchers and a shortage of practitioners in the field?

Dr. TERMAN. It is partly the way the funds have been appropriated and partly the enormous expense of developing new medical schools and expanding the present ones to handle more students. It comes to a matter of dollars. Dollars have been available for one purpose and they haven't been for another.

Dr. DEES. May I just add one point here, which I think is highly relevant.

At NSF we are extremely conscious of the fact that ours is a relatively minor role in the area of the life sciences, but I do want to emphasize one thing that I think ought not to be forgotten in this general connection—namely, that NIH, by virtue of its specialized mission, cannot have as much interest in, let us say, systematic biology, the classification of plants and animals, and so on, as they must have in some of the areas which are at the cutting edge of research that has to do directly with improving the health of the Nation.

As a result, I think that the comments that Dr. Terman has made, though basically correct, nonetheless do not speak to the question of the life sciences in general. They are primarily concerned with the life sciences as they are reflected through the eyes of a very competent administration that is concerned primarily with how to make sure that the human beings in this country, particularly, have longer and better lives.

Dr. CRAWFORD. I think, though, from where I sit in my university it is certainly true that both the medical and the basic biological areas are more nearly adequately supported, let me say, than the physical sciences and the engineering sciences.

Dr. KILLIAN. But there are still aspects of biology that are not touched by that program.

Dr. CRAWFORD. Oh, yes. And this, in turn, is more easily supported or easier to advance in than the social sciences or the humanities.

Mr. BROWN. I am interested in your criterion of adequacy, because this requires that we stipulate as to some preconceived level of what is adequate in these fields. Right now our criterion is based on the demand for scientific and engineering personnel in three or four major governmental programs such as the defense program, the atomic energy program, and the space program. Is that not true? Are these, as I think Mr. Vivian pointed out, essentially artificial criteria in view of the changing levels which could throw our projections out substantially insofar as future needs are concerned?

Dr. KILLIAN. Mr. Brown, we also must base our estimates on industrial needs that are not related to defense or space or other Government programs.

Mr. BROWN. It seems to me we must give increasing emphasis to our industrial needs because of the fact that perhaps this area has been shorted. The competition from these other areas has drawn scarce manpower away from these fields. However, I do not know how

we can be precise as to what the trend line will be in the private industry sector.

I am also deeply concerned about the emphasis which has run through all of your remarks that we are in a scientific and technological society today. As I think Dr. Terman pointed out, the quality of our civilization is determined or affected by this supply. However, if we are talking about just the physical sciences and neglecting the social sciences—the anthropologists and the economists—I would tend to differ with that. I think science is not just the physical sciences, it is much more than that. The quality of our society today is affected by excellence not only in the physical sciences, the hard sciences, but in all of the sciences that have to do with the study of man.

Does the Panel differ with that?

Dr. KILLIAN. Certainly not this member of the Panel. I agree with you completely and heartily. I am in favor, incidentally, of a National Humanities Foundation.

Mr. BROWN. I am not even talking about humanities. Humanities and sciences have traditionally been differentiated. Science has a broader connotation than mathematics, physics, and biology.

Mr. DADDARIO. Do you have a comment, Dr. Trytten?

Dr. TRYTTEN. I was going to say one of the striking things about undergraduate students is the degree to which they leave some of the hard sciences, as you are putting it, and move into some of these areas, and these are not necessarily the students of failing caliber, they are very good students, but somehow have the feeling that the problems of today lie in the area that you are talking about. There is a substantial amount of that kind of migration.

It is evident, for example, in a report put out by the National Opinion Research Center, I believe financed by the National Science Foundation, on the graduates of 1961. You can find some very interesting information in there about how students move around in the undergraduate years, shifted from one field to another, and some of these that you speak of as the hard sciences tend to lose out.

Mr. BROWN. We need to understand the motivation that causes this moving around. We may be pumping dollars into the hard sciences and competing with the motivation which more and more undergraduates have to move into a field which they feel is more relevant to the problems of society today.

Dr. KILLIAN. There is no doubt that this influence is taking place.

Mr. BROWN. I would like to know what the record indicates in terms of the increase or decrease in the percentage of graduates in the physical sciences during the last 10 years, as compared to the previous 10 or 20 years? Has there been a substantial increase?

Dr. DEES. The percentage has slightly fallen at the baccalaureate level in the physical sciences and risen in the social sciences.

Mr. BROWN. Does this not indicate what I am saying?

Dr. DEES. Yes, I think it does.

Dr. LECHT. Again, speaking in terms of the social sciences and needs, mention has been made of the need for better economic models and data, and I certainly agree. As a nation we are embarking on many new programs which presuppose a great deal of social science knowledge, in economics, in sociology, in psychology, in social psy-

chology. The war on poverty presupposes a great deal of knowledge as to motivations of people in attending schools, or getting a job, or maybe keeping out of jail, or getting rehabilitated. Our regional redevelopment programs presupposes a great deal of understanding of why people want to stay in an area or can move out, or how you get them to move out if you are thinking in terms of broader regions and promoting regional growth.

Similarly, our anticrime programs presuppose that we know how to treat criminals and why they are criminals. Obviously we have some of this knowledge, but we don't have nearly enough. We draw broad distinctions between hard and soft sciences, and I am sure those distinctions are there, but to a considerable extent the criterion must be the criterion of needs. In terms of needs, many, many things we are doing right now make it important that we improve our scientific knowledge in both the physical and the social sciences.

Mr. Brown. I would pose the possibility that one of the reasons we have such emphasis on the physical sciences is because of the relative ease of defining goals. We want to buy $5 billion of atomic energy science, $20 billion of space science, or something like that—the goals are fairly simple to define. They are not that simple to define in the areas which you are talking about. This is another reason why I am talking about the effect on national goals.

Dr. Killian. May I make a footnote on this.

In my own institution our experience has been in the last 10 years that the increase in election by students in various fields shows that management, economics, and, broadly, the field of the social sciences have gained more than any other field. A larger percentage of our students are going into these fields at the present time.

Mr. Brown. I wish we could learn to carry over some of the structure that we have in the physical sciences and engineering and feel that the social sciences are really sciences, and that public administration is really the engineering of political science and business administration is the engineering of economics as a science, and that social welfare and criminology and that sort of thing is the engineering of sociology and psychology.

Dr. Crawford. I think this is sort of a historical sequence. Certainly 50 years ago—I spoke of Maxwell's equations versus network theory—50 years ago, a little more than that, Maxwell's equations were a fine thing for basic physics, but their contact with reality was always with the fudge factor put in. You might design on the basis of science, but then you put in a factor of two. I think you call it a safety factor in engineering circles.

Physical science has grown, it has matured to the point where it does make contact with reality, and you can design a circuit, you can design a polymer in the chemical world, and predict in advance within let's say 5 percent what properties that unsynthesized compound will have. So it is not just a matter of being able to define the problem. I think it is simply the fact that physical sciences are perhaps 50 years ahead of the biological sciences, which are in turn perhaps 30 years ahead of the social sciences, and my 50 years and 30 years are—what was the term?—projections.

Mr. Brown. I think both of them are probably about 100 years or 200 years behind philosophy and the development of social goals that we should have.

Dr. KILLIAN. I think there has been a steady gain in qualitative aspects of the social sciences, and the quantitative which is very important. But there is still a long way to go to receive the effectiveness that they need.

Mr. DADDARIO. Mr. Vivian, we will be finishing in a few minutes, do you have any other comments?

Mr. VIVIAN. Yes. I think Dr. Terman made reference to the fact that international competition on the sale and distribution of products is increasing very rapidly, and we were going to have to pay a great deal more attention to the economic aspects of the subject of marketing. I think we are training far more people who are able to orbit space satellites than we are people who are able to continue to sell products overseas. I think this could be a disaster of no minor consequence.

I know, for example, there is the Sloan fellowship arrangement at MIT, and many people have their own programs. I am concerned with that partly because I have recently tried to sell products overseas. I noticed enormous differences in price which did not favor us. I think we might ask ourselves if we are doing enough in the colleges in terms of education for an international market. Are we, for example, training our engineers in the nature of the national markets and the price factor as influenced by different distributions of manpower and automation? Are we really training engineers these days or are we training people who have no contact with the commercial side of the enterprise?

I received an education in the engineering-economic relationship in 1945 in a school which at that time was teaching by the routine of the 1930's and they still had economics in the curriculum. Later, however, at MIT and Michigan I received almost no training on this subject because I was becoming an expert in Maxwell's equations.

Perhaps curriculum studies run by NSF might include engineering not as engineering per se, but rather engineering as a career and a predecessor to commercial enterprise. I think about 50 percent of all corporate managers are engineers by background.

Dr. KILLIAN. That is correct.

Mr. DOUGLAS. I think NSF has its hands full making for technical excellence. If you gave a man everything that he needs in life, you would give him Harvard Business School for a couple of years, you would give him the Foreign Study School out in Arizona for a couple of years; he would be in school for half his life. It is really too much to turn out every person this well rounded. Even the effort to give them the humanities, such as Dr. Killian has mentioned—I think the National Humanities Foundation—I don't know where I've been; I think it sounds like a wonderful idea—this could be a concern of another area. I don't think the NSF people should concern themselves with——

Mr. VIVIAN. Let me make one last point. If we are to guide our behavior today by the criteria of the 1930's, none of the major programs that are now in existence would ever have gotten off the ground. I think this evolution of rising expectations which prevails throughout the world shows itself in America through the total change in economic patterns, and I say, shall we go on with it?

Dr. DEES. In a different part of our shop from the one which deals with the course content improvement sort of thing, we have for a number of years been helping groups to look at the patterns of education. With respect to this very question that Mr. Vivian has raised. there is going forward at the moment, under the dean of engineering at Stanford (for the graduate component) and under Dean Hawkins at Purdue (at the undergraduate level) a set of studies designed primarily to look at exactly this broad question, not as it relates explicitly to international problems but as it relates to the question: "How should engineers be trained 5 years from now?" It is clear to those of us who have sat through discussions of this kind in detail on a number of occasions in the last few years that the so-called Grinter report that came out about 12 or 15 years ago, now, and which had a great deal to do with setting the patterns for instruction in the engineering sciences in institutions throughout the country, is viewed already as out of date. The pendulum swung probably a little too far in the direction of science as the main thing in engineering, with too little emphasis on the question of design and the question of economics, and all these other things that are imbedded in this very large complex which you have spoken of. These two studies are looked to by the engineering fraternity as possible ways not of determining what institutions will do in detail, but ways, rather, of helping the institutions to determine desirable trends over the next few years. The problem of imbedding, as Mr. Douglass has pointed out, into a 4-year engineering degree all these things is becoming an increasingly difficult problem. It may be, as Dr. Terman has pointed out, completely impossible, but it is certainly still true that a great many institutions are going to continue to turn out 4-year engineers, and they ought to be turned out in that period well adjusted to the times, and, as the dean of engineering at MIT has said several times, with a currency that will be valid for at least 10 years. So one can hope, therefore, that this kind of study will, in fact, by bringing together large numbers of people who have thought through these problems in considerable detail, have some impact on this problem.

Dr. KILLIAN. I think there is a correction factor working here to get back into the engineering motivation and interest, perhaps formally in the curriculum, a greater concern with cost and economic factors.

Mr. DADDARIO. In a sense, what Mr. Vivian is talking about is that which you have all touched upon on occasion—quality.

Mr. DOUGLASS. Just a very brief comment. I didn't mean to sound unkind on this subject. It is just a question of "something has got to give" as you get more in here, because really from the employer viewpoint a lot of employers want just good working engineers. They don't really want him to be a manager. They want him to be interested in his profession. We may get too involved in making him into all sorts of things that maybe he doesn't even want to be. This, I said earlier, should be up to the individual. There is obviously identification of excellence in people. If we can give a person that which he needs, this is fine.

Dr. KILLIAN. One of the conclusions reached in this study is that the most acute shortage was of those men who had a deep insight into technology but in addition the management skills that would put the team together to really make it work.

Mr. DADDARIO. I would have liked to have discussed NSF's science development programs, and whether or not you support this program. I think it might be a step toward the accomplishment of these centers of excellence that you have mentioned. However, we do not have time to go into it now.

I want to apologize to all of you for keeping you so long. We have gone considerably beyond 12 o'clock. There is now a rollcall in the House for which we must qualify, so we will stop at this point.

I want to thank all of you for what has been an exhilarating discussion, and one which has been very helpful to the committee.

This committee will adjourn until tomorrow morning at 10 o'clock in the same place.

(Whereupon, at 1 p.m., the subcommittee adjourned until Thursday, August 5, 1965, at 10 a.m.)

NATIONAL SCIENCE FOUNDATION

Seminar on Science in Small Colleges

THURSDAY, AUGUST 5, 1965

House of Representatives,
Committee on Science and Astronautics,
Subcommittee on Science, Research, and Development,
Washington, D.C.

The subcommittee met at 10 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. Daddario. This meeting will come to order.

This is our next to last day of hearings on the National Science Foundation. Dr. Haworth will appear as our final witness on August 19.

I am pleased to welcome today Dr. Sanford Atwood, president of Emory University, Dr. James P. Dixon, president of Antioch College, Dr. Katharine McBride, president of Bryn Mawr College, Dr. John E. Sawyer, president of Williams College, and Dr. Richard H. Sullivan, president of Reed College.

It is our intention in this seminar this morning to look into the relationship of the small colleges to science and research, and their relationship to the National Science Foundation. This committee is concerned with the place the small colleges have in this Nation's scientific research programs, and the role it will play in the future.

We had an opportunity yesterday to discuss the question of scientific, engineering and technical manpower with a panel which added a great deal to the hearings of this committee. I would like to use the same format with you distinguished participants this morning.

Would you care to start, Dr. Atwood?

STATEMENT OF DR. SANFORD ATWOOD, PRESIDENT, EMORY UNIVERSITY

Dr. Atwood. Thank you, Mr. Chairman, ladies and gentlemen.

The theme that all of us on the panel are emphasizing today highlights the college—the small college of liberal arts and sciences. We are proclaiming its vital role in the best possible preparation of the Nation's sorely needed scientific brainpower. In effect, we are saying that Government funds in support of science training are just as important for the good colleges as they are for the good universities. If the Government neglects this valuable collegiate resource by funneling

disproportionate aid-to-science funds to the already oversized and strongly research-oriented universities, it will be cutting off Uncle Sam's scientific nose to spite his new space face.

Although we're joining in a chorus, each of the panelists properly should stress his or her particular verse. The situation at Emory College within Emory University is a significant deviant from that of the other colleges represented among today's seminar participants. The pattern from Emory is that of the small liberal arts college, which like the others is very select in its admissions and very high in its standards, but which at the same time is nurtured in the congenial atmosphere of a medium-sized university where there are unusual opportunities through intimacy for interdisciplinary research and teaching.

Emory is a university that includes not only the traditional master's and Ph. D. programs but also a full array of graduate and professional offerings such as medicine, law, and business. We are granting more graduate and professional degrees than baccalaureate degrees, and approximately two-thirds of the former are at the doctoral level.

Last year we renamed the undergraduate college. It used to be called the College of Arts and Sciences, but now it is called Emory College. This was done purposely to accent the original and crucial role of the undergraduate college, now making its way in a university environment. Emory began as a college in 1836 in Oxford, Ga., and it didn't aspire to be a university until 1915, when it was granted a second charter and the campus was moved to Atlanta.

In recent years, the college has rapidly increased its selectivity, so that the incoming freshmen have been chosen with essentially the same standards as those of the best schools in the country. If this year's graduating seniors were to apply again as freshmen, over one-third would be below the cutoff point for admission. Even so, more than 80 percent of this year's B.A. and B.S. male graduates are planning to engage in graduate and professional study.

My point is that this kind of high-level undergraduate training—for science and all other fields—can and must be duplicated in every region in the Nation. Only in this way will we foster the best opportunities for discovering and developing the full mental resources of this country, which we know are not distributed with any geographical priorities or with any allegiance to race, creed, or color. And lest you're worried about the kind of teaching at Emory or other such colleges, let me assert that the faculty resources necessary for top-level education of such outstanding students have been and are being attracted to this kind of college within a university.

Perhaps I can illustrate with a few case studies about students and their professors. First, the story of Jim Bolen. Jim was reared in a small town in southeastern Georgia. The youngest of four children, he was supported through school by his mother, who works as a secretary. He had an excellent high school record—3.8 average on a 4-point system—and he engaged in a wide variety of extracurricular activities. His SAT scores were in the 600's but there was no basis for predicting his spectacular college record. Every grade that he received during his entire college career was A, except for four B's, and he was graduated last June with a major in chemistry and No. 1 in his class. Throughout his 4 years he was involved in many activi-

ties outside of the classroom, including several roles in student government and the presidency of his fraternity. He received all top honors, such as Phi Beta Kappa.

Jim and Emory first came together in the summer of 1960 when he attended the NSF High School Institute. When he entered as a freshman in the fall of 1961, he was placed in an honors section of general chemistry, and he was consistently top man in his section. At the end of his freshman year, he entered the NSF undergraduate research participation program, an opportunity that is usually reserved for upperclassmen. Jim elected to work with Dr. J. H. Goldstein in the area of nuclear magnetic resonance. His work was so outstanding that Dr. Goldstein hired him as a research assistant during the 1962–63 academic year. He has continued his research as an NSF participant in the summers of 1963, 1964, and 1965, and during his senior year he took a year's course in quantum mechanics that usually is limited to second- and third-year graduate students.

His research has centered about structural studies of molecules of biological significance such as cytosine, pyridine, and the pyrimidines. He has given oral papers for the past 2 years at meetings of the Georgia Academy of Science. The general caliber of his research performance has been that of a Ph. D. candidate. This fall he probably will enter the Johns Hopkins Medical School, although he is trying to work out a plan for a combined M.D. at Hopkins and a Ph. D. at Emory.

There is no doubt about the NSF program being instrumental in focusing his attention on research and giving him the opportunity as an undergraduate to work with a distinguished professor in a very close personal manner. Without the assistance he received from NSF, Jim Bolen could not have utilized his abilities to the fullest extent.

Another case demonstrating the value of summer NSF programs is that of Bob Harrison. He was a participant in the geology section of the NSF-sponsored summer science institute for high school students at Emory in 1963. At that time he had completed the 11th grade at Venice High School in Florida. Because of the NSF experience, he returned to Emory in the fall of 1964 as a freshman intending to major in geology. Last spring he was awarded the honor of being the freshman with the highest academic average. It is significant that he first came in contact with geology through an NSF program and was attracted to Emory to major in this subject.

Likewise in physics, the undergraduate NSF research program is reaching into the freshman class. During this past year, Robert Warnock, a freshman from Alabama, devoted a sufficient portion of his time in the Solid State Laboratories to prepare and present a research paper in the area of thermoluminescence before the senior section of the Georgia Academy of Science.

More exciting, however, is the case of a senior, Wallace Mathews, who last year conducted a series of experiments on room-temperature optical bleaching of KCl during gamma irradiation. It's of interest to note that he used the hospital's teletherapy unit for his irradiations on weekends and during evenings when there was a light patient load.

Wallace is a native of south Georgia, where his father is engineer for the Thomasville Waterworks. As a career scholar with Pro-

fessor Mallard, Wallace studied the mechanisms of color center bleaching induced by relatively low radiation dose levels in alkali halides. At the same time, the Solid State group at Oak Ridge and the Hazards Control Department at the Lawrence Radiation Laboratory, studied the same behavior at very high radiation doses. Wallace's data matched beautifully the Oak Ridge data in the region where the experiments purposely overlapped. Strikingly unexpected results of his unique experiment in the low-dose region substantiated a mechanism for vacancy-interstitial pair production of F-Centers and weakened the case for two other competing models. Wallace presented his results before the American Physical Society at the Washington meeting this spring, and they will appear in the Physical Review in a report on the Emory-Oak Ridge experiments.

This summer Wallace is assisting with the NSF undergraduate research participation program, and in September he will begin graduate work at Boston University.

Similarly our mathematics department has conducted NSF institutes for high school students every summer since 1960. One student, Wayland Brown, who was in the first institute, has just graduated from Emory with high honors. He has been awarded an NSF fellowship and a Woodrow Wilson fellowship and is entering the University of Washington to work toward a Ph. D.

Another former undergraduate math major, Russell McMillan, was awarded an NSF fellowship at the University of Wisconsin. Currently, he is an associate professor at the University of Virginia and a Sloan fellow and is regarded as one of the best young topologists in the country.

The mathematics department also has conducted in-service institutes and summer institutes for high school teachers with NSF support since 1957. Because of this NSF support, a new degree program, master of arts in teaching of mathematics, was organized, and presently is in a very flourishing state. Approximately 28 teachers have graduated with this degree, and this summer there will be 12 more. This program has significantly influenced the quality of mathematics teaching in Georgia high schools, as demonstrated recently in the Mathematical Association of America national examination, when the three top schools and top students in the State had teachers trained in this program.

From the examples cited, and many more like them, it is obvious that Emory and other small colleges are serving well as grassroots centers for the selection and training of scientifically superior students. The small colleges, geographically distributed as they are, can reach into areas and tap pools of potential scientists that would not be reached by the few large university centers of excellence. While such large university centers are being developed, the National Science Foundation might well support, as an equally important investment, those small colleges that themselves are geographically well distributed centers of excellence. Only in this way will we provide adequate opportunities for finding and developing the best scientific brains everywhere.

Mr. DADDARIO. Dr. Atwood, you touched on these case histories. How would you relate that to further progress? Do you have any idea how these case histories can be improved, and how we can attract

not just those of such high rating, but others who can still be competitive?

Dr. ATWOOD. To do the job, we need large numbers of such institutions, and we need them well distributed geographically. The best opportunities will come in those schools that are select in their admissions and provide this stimulating atmosphere which steers the students toward graduate work.

Some of our colleges are preparing a disproportionate number of boys for graduate and professional work, which, after all, is where the scientist is trained. Such colleges need help from the National Science Foundation, whether it is undergraduate research participation, whether it is grants for faculty research, whether it is equipment funds, whatever will attract the good professors and thereby attract the good students.

Mr. DADDARIO. You like, then, what has been done, but you feel there is room for improvement?

Dr. ATWOOD. I like very much what has been done. I would like more of it.

Mr. DADDARIO. Dr. Dixon.

STATEMENT OF DR. JAMES P. DIXON, PRESIDENT, ANTIOCH COLLEGE

Dr. DIXON. I shall add only a brief chorus, if I may, to Dr. Atwood's testimony about the effectiveness of the relationships which we at Antioch College have had with the National Science Foundation. The thrust of my remarks will not be so much to explore the question of regional centers of excellence as to explore the possibilities that the small liberal arts colleges may indeed be a primary source of scientists for many years to come, and my remarks are an effort to examine the possibilities of additional support by the National Science Foundation of undergraduate education as a primary source of scientists.

Historically the small liberal arts colleges have been highly productive of scholars in the physical and social sciences, and despite the rising enrollment in the large, publicly supported university, the burden that will be placed on small colleges will be consequential in the decades ahead. The master plan for higher education in Ohio, for instance, calls for doubling the enrollments in the private colleges in the next decade. The small liberal arts college will continue to be an important source for recruitment and pretraining in the disciplines of physical and social sciences. It will no doubt continue to do this in an environment that is heavily weighted with the concern for the liberal arts, which is to say that such a college will be oriented to treating all of life as if it were vocational, not merely teaching the student in the discipline in which he chooses to specialize.

One senses, in examining the awards of the National Science Foundation fellowships, that very little emphasis is placed upon the necessity of making awards to graduates of liberal arts colleges. This suggests that the National Science Foundation puts a very heavy emphasis at the undergraduate level on preprofessional training, and that it may be missing the opportunity to support explicitly the primary function of the liberal arts college, which is to educate the whole man. In missing this possibility, it may be failing to uncover creative

scientists who will not, at that point, present the most elegant preprofessional training credentials because they will have chosen to use their undergraduate opportunity to extend their learning beyond their major fields of interest. The National Science Foundation may also be failing to support the education of citizen leaders who are equipped to manage humane science policy.

In recent years, there has been a modest growth in the superiority of research in the small liberal arts colleges by the National Science Foundation, in another dimension these colleges have been very successful in assisting the National Science Foundation in the admission of the improvement of the teaching sciences in the secondary schools. But the small liberal arts college has special problems. Feeling the responsibility to introduce students to the widest possible horizons of knowledge, it lacks the high degree of specializations in its faculty that characterize the large university.

Indeed, in the physical and social sciences, it may be safely said that faculty members in the liberal arts colleges are regarded by their university colleagues in the disciplines as second class. The college teachers cannot compete with their university colleagues for the political roles in their fields that make them effective in negotiating national policy at the Federal level.

Few small liberal arts colleges have thought that they could afford many faculty members whose principal occupation was research, and the effort to fit scholars into a combination of teaching, counseling, scholarly and research roles often results in the fragmentation of their time in such ways as to make it unreasonable to expect them to carry on extended research activities.

Furthermore, the small colleges lack the resources to invest in physical facilities and libraries on a scale which can compete with universities. The small liberal arts college, then, has special administrative problems in managing the time of its faculty in order to accommodate the research and investigation. It must be said failure to do this has often made it difficult for such colleges to recruit a faculty that by its own standards would be adequate.

Some of these problems of scale might be overcome if it were possible for the National Science Foundation to develop a program of institutional grants, and here I don't mean the present program of institutional grants, not a program which is based upon a percentage activity of what is already underway, but a novel program of institutional grants that would permit the small colleges to rearrange teaching time and emphasis to the best advantages of the undergraduate students and the development of the faculty. Such grants, too, would simplify the problems of small colleges in dealing with the Federal Establishment. Universities can have on their staffs persons who specialize in such relationships, but the small college either must depend on the ingenuity of its faculty members to find support for their own projects, or must wait to be sought out by the Federal agencies.

The relationship between the National Science Foundation and the small liberal arts college deserving to be greatly strengthened is that for the preparation of teachers for college teaching. So-called teaching interns can be added to the programs of the small college rather readily, and the environment of the liberal arts college, at least in the eyes of the college, is particularly suited to such internships, for as

yet scant attention is paid in graduate schools to the preparation of graduate students as prospective professors.

Finally, much more could be done in developing relationships with groups of colleges for all small colleges will be plagued with unevenness of quality in their faculties and need the opportunity to draw on each other's strengths. Such a consortium is the Great Lakes College Association, made up of colleges in Ohio, Michigan, and Indiana, which is in the midst of a very successful internship program in chemistry and biology financed by a private foundation. But it wishes to go beyond that to find ways to improve the quality of all undergraduate teaching. Such consortia should be stimulated to specialize and learn how to use each other's resources, particularly at the advanced undergraduate years.

The relationships between small colleges and the National Science Foundation deserve to be more intimate and effective than they are at the present. Not only should it be possible to extend present relationships in support of faculty and undergraduate research, and the improvement of the preparation of teachers at all levels, but because of the problems of scale the possibilities of making institutional grants designed to draw from each college its greatest productivity should be fully explored. Such institutional grants, it should be noted, should not be made just to colleges that have achieved excellence, but to any institution that can demonstrate a plausible program for improvement.

Thank you, very much.

Mr. Daddario. When Dr. Wiesner testified here a few days ago, he threw out the suggestion that to help in this faculty arrangement that perhaps a science teaching corps might be established to fill these needs. Do you have any thoughts on that?

Dr. Dixon. I haven't thought about it. I suppose one's first response is a little defensive. One observes the high mobility of faculty members, and if such a corps were to increase the mobility of one's faculty members, one might have some reservations about it.

I take it that he had in mind a program in which the preparation for membership in this corps would be supported in some way by public funds?

Mr. Daddario. Yes, I think so. We did not go into it in any depth, but you have put forth some suggestions here in this regard. I just thought that perhaps we should add Dr. Wiesner's suggestion as another avenue to look into.

Dr. Dixon. We tend, I think, in our liberal arts colleges, to sometimes disguise the inadequacies of the level of quality which we have in the physical and social sciences. For most liberal arts colleges it is extremely difficult—even for colleges of excellence—extremely difficult to get and hold a faculty that is adequate to do the preprofessional training that the universities will regard as appropriate for the admission of graduate students. We have trouble saying this publicly because it is with a sense of concern that we have had to admit this weakness.

The places where we have real peril in quality of faculty is in the physical sciences and more recently in the social sciences. I think this is why it is in our own self-interest to be concerned about the teaching of teachers and in our own self-interest to get behind any national program that would help do so.

Mr. DADDARIO. Our next participant is Dr. Katharine McBride. She not only is president of Bryn Mawr College, but also a member of the National Science Board, and therefore has had a very close relationship to the development of the activities within the National Science Foundation.

Dr. McBride.

STATEMENT OF DR. KATHARINE McBRIDE, PRESIDENT, BRYN MAWR COLLEGE

Dr. McBRIDE. Mr. Chairman, I appreciate the opportunity to meet with my colleagues on the Panel and with the members of the Committee on Science Research and Development, under your chairmanship. I thought that I might present to you a case study which would show the variety of NSF programs in one college, and that is what I have chosen to do.

First, I should perhaps say briefly that Bryn Mawr is a small institution, with about 1,100 students, about 115 members on the faculty. Among the students, 750 are undergraduates, all women, and 350 are graduates, both men and women. So, like Emory, we are talking about a small institution. Ours happens to be called a college, but it is a combination of undergraduate college and a graduate school. About 15 percent of the undergraduates take their degrees in the natural sciences and mathematics, about 25 percent in the social sciences. Among the graduate students, the percentages are just about reversed. About 26 percent take their degrees in natural sciences, and about 16 percent in the social sicences.

Members of the faculty at Bryn Mawr are interested in support for science and social science that will help us do more than we could otherwise do in basic research, in the support of graduate students, and in the development of better teaching.

Among the Federal agencies, we depend almost exclusively on the National Science Foundation, the Public Health Service, and in the field of social work, the Children's Bureau, also. We are not interested in contract research and almost never do any. In Federal grants of all kinds, we receive about $500,000 a year. That is about 10 percent or our total budget. The amount from the NSF in recent years ranges from $115,000 to $246,000. Those figures represent the range for the last 3 years.

We look to the NSF primarily for help in the support of basic research and in the support of graduate students. Members of the faculty have research grants in five different fields in science and social science. A research grant usually, as you know, provides funds for summer salaries for faculty members, part-time assistance for students and some equipment. We do not ask for winter salaries for faculty members. There is an occasional exception to this, and one that I should mention later.

The cooperative fellowship program and the new graduate traineeship program are helpful in the support of a few of our graduate students in the sciences. Other graduate students, a larger number, are supported through the part-time research assistantships which are part of the research grants to members of the faculty.

Grants under different programs of the NSF that are most useful to us for the undergraduate school are the undergraduate research participation program and the undergraduate instructional equipment program. In each of these we have grants in three different fields.

In the undergraduate research participation program, as has been noted, able undergraduates are chosen for an 8-week summer period of "independent study." Independent study is done in close collaboration with a professor and represents a kind of preview of the experience the student expects to get in graduate school, where concentration on a subject is possible and close collaboration with the professor is attained.

The students in this program, as has been mentioned for the students at Emory, are usually students who plan to go to graduate school, and this summer on the undergraduate research program confirms their choice.

The NSF institutional base grant has been mentioned. It is an unrestricted grant based on the total of all research grants made to the institution the year before. At Bryn Mawr it is expended on the recommendation of a faculty committee, chiefly for the following purposes: To purchase equipment that would not fit into any individual research proposal; to subscribe to additional scientific journals; to give partial support to younger faculty members or graduate students who are getting their research underway.

This, in our experience, is one of the most useful of all NSF programs. The amount is not large. In our case, for 1964, for example, it is $17,430. I looked at the grants to the other institutions here, and I find that Reed exceeds us all, so after the meeting I propose to ask my colleague Dick Sullivan how he manages this amount! But those unrestricted dollars are stretched by our faculty committee just as far as dollars can stretch.

We have had a few other grants for special purposes and I shall include them to show the range of NSF support. We have had one toward the cost of the research area in the building of the physical sciences which was completed in 1964. We have had two for in-service institutes for teachers of physics in secondary schools; we have had one for the development of a course in chemistry and physics which is still underway. That course involved the exception to our policy of not asking for NSF grants toward faculty salaries during the college term. To develop the course, two faculty members were released, half-time: that is, paid by the NSF grant. The grant will not be large enough to support them in the evaluation of the course, and its preparation for possible use by other institutions, and that we shall support from our own funds.

We have also had a grant jointly with Haverford College to develop a small computer center for the two institutions, which has now been in operation, I think, for 3 years.

It is, of course, hard to make an overall estimate of the effects of NSF support on a single college in the last 10 or 12 years. We have had at Bryn Mawr the same problems other institutions have, stepping up the work in science through grants increases college costs beyond any increase in the overhead. Stepping up the work in the sciences gives the faculty in the sciences some advantages over fac-

ulty in other fields, notably summer salaries. On the whole, however, the advances that can be made through the NSF programs greatly outweigh the problems involved.

Certainly we find that the faculty are more active in research than they were earlier, and that they are getting on faster, chiefly because they have more assistance and in general better equipment.

Certainly the NSF support with that of other agencies has substantially increased the number of graduate students.

Certainly also more people, both students and faculty, work a longer year than was true 12 years ago. Two weeks is the typical vacation now in the sciences and social sciences.

We also believe that the college that has not seen this kind of progress in the sciences would have the greater difficulty in making new appointments in these fields.

Thank you, Mr. Chairman.

Mr. DADDARIO. Thank you, Dr. McBride.

It is a little bit off today's subject, but we on occasion have referred to the relationship of the National Science Board to the Director. It would be helpful to us, I think, to get your view as to whether or not the National Science Board, as presently constituted, can on a part-time basis properly fulfill the role that was originally prescribed for it in the National Science Foundation Act of 1950.

Dr. MCBRIDE. May I answer that by going back a little bit to earlier years in the Foundation when I was, as Mr. Sullivan is now, a member of the Divisional Committee on Scientific Personnel and Education.

The Director met with that Committee usually and gave that one of the major committees of the Foundation a chance to discuss policy, program development, budget, and other aspects of the Foundation's program. I felt in sufficiently close touch with the work of the Board at that time to know that there is a great deal to be added to the report that was prepared for your committee as a preliminary to this review that you have undertaken.

For instance, I missed in that report the program development that the NSF staff and Board and committees work very hard on. The author of the report is likely to say that such a program appeared in such and such a year. I suggest that that program didn't appear without the most tremendous amount of preliminary work and exchange with the scientific community, and the tremendous involvement of the Board, its committees and the staff in the development of program I would like to emphasize.

More specifically in answer to your question in the present, I think you should note that we meet not only as a board but as a series of committees. I happen to be on the new Committee 1 of the Foundation, which is concerned with current program. We meet once a month in addition to the Board meetings, and we review major problems before the Foundation; for example, the situation in relation to the rapid development of the need for computers and the problem that we will face, not only the NSF but the Government agencies more generally, in the development of university computer centers.

I would say in general in answer to your question that we have a pretty extensive opportunity for discussion and exchange of opinion.

Mr. DADDARIO. The point has been raised that the chairman of the Board ought to be a full-time position, and that the Board have its own

full-time staff separate and apart from the staff help it now receives from the Foundation. What is your thinking on that?

Dr. McBride. I would question what the relationship of a full-time chairman and a board would be to a full-time director. It seems to me the agency should have one operating head and not two, and I would find it hard to see how a full-time chairman of the board would find himself in relation to the director.

Mr. Daddario. The suggestion that Dr. Walker made was that the director would be the operating head and that the chairman would perform the policy function somewhat in the nature of some corporations. The example of a school which used this management arrangement was MIT. It has a chairman and a president which apparently work harmoniously.

The other suggestion was that perhaps there should be a full-time staff, not a large staff, but a staff which might be available to the members of the board and the committees.

Dr. McBride. The staff in the contacts I have had with the Foundation is apparently able to find time to both meet with the board and prepare the materials requested by the board. We feel very close to the staff.

Now how we would use an additional staff I am not sure. As you talk about full-time and part-time appointments, I should perhaps say that some of us on the Board wonder whether maybe the part-time part of our work isn't our other job.

Mr. Daddario. I would think that you would find yourself in that position very often.

Thank you, Dr. McBride.

We will next hear from Dr. John E. Sawyer, who is president of Williams College.

I would just like to comment on the fact I have working in my office this summer a boy from my district who is a student at Williams College. I am happy to have him although some people feel me disloyal not to have a student from Wesleyan.

STATEMENT OF DR. JOHN E. SAWYER, PRESIDENT, WILLIAMS COLLEGE

Dr. Sawyer. Mr. Chairman, I am delighted he had that experience. He spoke to me before the meeting began and expressed his great interest in it.

To you and members of the committee I would like to echo my appreciation of the interest of this committee in the small liberal arts college. I think there is, as Dr. Dixon has very well said, serious danger that this important part of the structure of American higher education and of the supply stream of qualified scientists will be neglected in comparison with the highly visible capacities of the large research centers.

I think it would be a very great loss for America if science should wither at what has been a major source of young scientists and what is a very important part of our educational strength.

I would like to say that I think the NSF has done not only a helpful job but an outstanding job in strengthening science in America, and that American education is better for what it has done. I

would like to say that clearly because I am going to focus my remarks on ways in which I would like to see some diversion or increase of its effort in support of the liberal arts college.

Miss McBride has outlined very well the kinds of things that it is now doing. I think there is an acute need for it today more. I would like to speak of this under three main headings.

First, there is clear evidence that there is more capacity to give advanced training in science, Ph. D. training in this country, than there is supply of qualified candidates. I could quote from a report of the American Chemical Society a year ago:

> The numbers indicate that there are at present places available for graduate students, more places available than there are qualified applicants. In short, a rather desperate competition for students exist and probably will continue for some years.

And a statement from the American Physics Institute to the same effect:

> Physics is facing an increasing shortage of adequately trained baccalaureates, to meet the requirements that progress will place on the field.

That is, there is more training capacity for advanced work than the supply of well-trained undergraduate candidates, and it is right here that the group of colleges represented and those they are speaking for can make their contribution.

Second, I would urge the importance of sustaining first-class science at the strong liberal arts colleges and the value of having the Nation's future scientists come to science and come to either their professional or executive responsibilities with this background of education. It is important for scientists and nonscientists to have a broad liberal education and the high-quality independent colleges provide an instrument unique to this country, that has been built up and equipped to supply this.

Further, as Dr. Dixon indicated, a mainstream of future science teachers comes from the small liberal arts college. Students catch the spark, and Dr. Atwood referred to this, they catch the spark of a personal kind of teaching relationship that gives them an interest in this life commitment to go on into a career of teaching science to youngsters, giving a cumulative effect to this investment.

Third, I think it is extremely important to the future of this country that scientists not become educated in a world unto themselves, exclusively in a few large technical schools or universities, withdrawn from communication with other leadership groups and with the mainstreams of American life.

I think the liberal arts colleges are particularly suited to offering good science instruction on a broad liberal arts base and contact with men who are going into careers like yours and the many others that are necessary for a democratic society to cope with this modern world.

Mr. DADDARIO. Dr. Dixon referred to that, I think, as teaching the whole man.

Dr. SAWYER. That is right. And the kind of dedication, the number of science teachers that have come from small colleges are amply demonstrated. There is a study by Knapp and Goodrich a few years ago that shows the fertility of the small liberal arts colleges in producing scientists and the teachers of science.

The experience of providing good science education is a massive burden for the small colleges that take it seriously.

It is important, I think, to sustain a leadership group, and I am going to dissent I expect from people on both ends of this table in this respect. While geography should be respected, and any strong regional institution should be encouraged, I think the basis of support ought to be standards of excellence and potentials of excellence, the capacity to do the job; and because, for instance, in the Northeast there are more institutions with a strong past and strong potentials, I think it would be shortsighted to penalize them for this factor. Their capacity to feed students into this supply stream and to sustain this endeavor is the important thing. America needs the sum of these resources.

Now the expenses are real, and the ways in which NSF can be helpful Miss McBride has reviewed in a case study. I would like to quickly and briefly mention five kinds of things, all of which support what Dr. Dixon said: Increasing the capacity of the small college to retain and attract the able scientist who also wants to teach but in teaching does not want to cut himself off from research opportunities in his professional field.

I will briefly mention five here. First is clearly and importantly physical facilities. The costs of building new science buildings, new science centers, are pressing on all of us. We had a program which had very favorable staff response at NSF but which they were unable to fund when their own budget was cut in ways that precluded new programs, and among the new programs was one in support of undergraduate science institutions.

This hurt us directly and others in similar need of partial help in the financing of new science buildings. This was a particularly imaginative interdisciplinary science center that a group of our younger faculty had come up with, and it impressed me as an extremely fertile idea.

The second, related to this, are equipment and research assistance needs where NSF is helping on a limited scale now in both equipment and, as Miss McBride said, in participation in research in the summertime but where an expansion of this could be directly helpful.

Third is a balancing of teaching loads where the small college often has to ask of its faculty a much larger teaching burden than the large universities and the research centers. The availability of funds under the kind of new institutional program that Dr. Dixon suggested here would allow intelligent management of relief of teaching for a semester or a lightening of load when a young scientist has some particularly important work he wants to bring to fruition. These are opportunities that we could develop with the kind of institutional grant which he alluded to.

Fourth is contact with their professions, to help enable them to take time off and go to Brookhaven, or go to MIT for a semester or a summer or travel during the year or whatnot that will enable a man to keep abreast of his field. This is not only important for him, but critically important to transmitting the spark to the young people in college who are working with him in science and who are catching hold of the excitement there is in serious scientific research.

And fifth is summer compensation. There has grown up an arrangement under which people benefiting by Government contract, NSF and other grants, have a compensation during the summertime, typically two-ninths of their salary, which supports their summertime research.

As Dr. Dixon indicated, it is often less easy for even a good scientist at a small college to formulate the program, go through all the apparatus of getting a special grant. Here again an institutional grant could help in making this available, and I think you could with confidence feel that those small colleges—I think NSF knows well where centers of strength are—that are first class and are seriously concerned with sustaining first-class science would use these funds responsibly.

Hence, I would strongly urge not only the good record of NSF but the further support of activities that could strengthen science in the strong liberal arts colleges for the reasons I have briefly covered.

Thank you, very much.

Mr. DADDARIO. Thank you, Dr. Sawyer.

Do you have any comment, Dr. Dixon, on the question of geographical distribution and the helping of schools which have not as yet deserved the label of excellence, but which have the potential to develop excellence?

Dr. DIXON. I have thought a bit about this. I suppose it is not an either/or. To approach it sensibly one has to recognize that there are parts of the country that behave as regions, there are institutions that behave as regional institutions and tend to draw in concentric circles their students to them. There are, on the other hand, colleges—take ours as an example, if I may—which are in no sense regional. Located as it is in Ohio, not more than 5 percent of the student body comes from the State of Ohio. It is regional only in the sense of its potential cooperation with other institutions.

So you have the prospect of regionalization that is mentioned in the new Hampshire College, for example, that we have heard about in this last day or two.

I should think this is not either/or, that where regionalization can be demonstrated, it should be supported, and where potential excellence can be demonstrated, even though regionalization cannot be demonstrated—it, too, should be supported.

Mr. DADDARIO. Then there is not such a disagreement.

Dr. SAWYER. I would echo that idea. I would certainly say there is a strong case for supporting regional excellence where it exists. I would just not want to exclude other centers of strength, because there happens to be some concentration in given geographical areas.

Mr. DADDARIO. You were just being somewhat protective?

Dr. SAWYER. Yes.

Mr. DAVIS. I would like to point out that one witness heretofore has expressed it this way: It is unquestionably to the best interest of the country that we preserve the peaks that we have, and we should dedicate our efforts to filling in the valleys.

Dr. SAWYER. That is right.

Mr. CONABLE. The only problem with this is there is some limit to the resources available, and what we do at the peaks may have some impact on what we can do in the valleys.

I would like to ask Dr. Dixon if most of his students do not come from the Northeast, however.

Dr. DIXON. They come from the major metropolitan areas in the United States, except those metropolitan areas in the southeastern United States. They are rather evenly distributed.

On this question of regionalization, David Riesman has a theory about this. It is called "The more, the more," and his young——

Mr. CONABLE. Research begets research.

Dr. DIXON (continuing). And his young colleague, Christopher Jenks has a collateral theory, "The less, the less."

Mr. DADDARIO. In this regard, what comment do you have on the limitation which Congress has imposed upon NSF on the number of fellowships which can go to residents of any one State as it affects such areas as New York and California. Should there be a limitation?

Dr. SAWYER. If that is addressed to me, my own study of this problem and exposure to it has been more in terms of institutional needs. I have not studied that, and I do not know whether that is a limitation. I can see, perhaps, a need for a balancing of both here. It would certainly seem to be losing a source of talent, unless other forms of support are available, to cut off extremely able young men simply because they come from a given area.

Mr. DADDARIO. I would imagine all of you would agree with that proposition?

Dr. SULLIVAN. I might add this, Mr. Chairman, it seems to me, particularly at the graduate level, that limitations by particularly geographical subdivisions are especially unfortunate.

I think they are more unfortunate there, where we are producing a national resource that is highly mobile, where there is not necessarily much relationship at all between the geographic origin of the graduate student and where he will serve this country directly or indirectly. It is at this level that I think we should be particularly cautious about geographic divisions.

When you come back to the possibility that the Federal Government would be financing more undergraduate scholarships, then I think geographic considerations would be more relevant because by and large our students are attending high schools in the areas in which their families reside. This is less true once they are in college, even less true at the graduate level.

Mr. DADDARIO. I am glad you made that comment, Dr. Sullivan. I would appreciate it if you could just proceed with your prepared remarks.

STATEMENT OF DR. RICHARD H. SULLIVAN, PRESIDENT, REED COLLEGE

Dr. SULLIVAN. Mr. Chairman and members of the committee, I share the interest and pleasure of my colleagues here in being invited to speak to you today and feel like them that the committee is certainly to be commended for its interest in the effects of Federal science policy on the liberal arts colleges. I am sure your concern is recognized and appreciated well beyond just the members of this group who are here, today.

I think I would like to make it especially clear, like my colleagues, that while I am here by your invitation, I am here also as a friend of the National Science Foundation, which, in my judgment, like Dr. Sawyer's, has performed in an outstanding manner over the past 15 years. It seems to me that that performance by a higly competent professional staff has been achieved through generally a broad understanding of the needs that do exist today in our colleges and universities.

In part, that understanding has been aided in an important way by the use of and the employment of college and university personnel on leaves of absence from their home institutions and by the use of an extensive and thoughtful system of advisory committees. I might, in view of a few comments by my colleagues, mention one or two things about Reed College, simply as background for what I will try to say. Like Antioch and Williams, I believe more than like Emory and Bryn Mawr, Reed has been traditionally an undergraduate institution. We now have approximately 900 regular, full-time undergraduate students. Like those described from Antioch, they are drawn really from wide national spectrums, geographically.

I think Reed has had a somewhat unusual record in two respects: Traditionally it have been quite strong in science, and 40 to 50 percent of our graduates will, in a typical year, have majored in mathematics, physics, chemistry, or biology, which is an unusally high percentage for the independent liberal arts college.

Secondly, a very high proportion of our alumni have tended to go into teaching and research and to furnish the manpower for college and university faculties, a trend that one of my colleagues here has already alluded to.

One graduate program that I have been very happy to see develop very rapidly, has increased in terms of degrees granted by sevenfold in the last 6 years, which is quite a rapid rate of increase, even though the numbers are small, and this is the master of arts in teaching degree, which has been directed toward the better preparation and updating of groups of people who are particularly interested in secondary school teaching, and that degree program has paralleled the efforts of many of our faculty in the national curriculum development at the secondary school level and other programs of that sort.

We have had approximately the same variety of assistance and grants from the National Science Foundation that Miss McBride described for Bryn Mawr, so that our experience with the Foundation has been rather extensive.

It seems to me that the understanding and appreciation of Congress, sympathetic to the very large responsibilities of the Foundation, has also provided in that agency an administrative flexibility that is somewhat unusual in the Government. The Foundation has been allowed, with few specific restrictions, and most of those I think I would tend to oppose, to modify its programs when needed, expanding and contracting as experience and current necessities would suggest.

Over the years its program has been broadened to include institutional grants more than before, programs aimed primarily at the undergraduates more than in the past, and fields of knowledge other than the "hard sciences" where they started in the early fifties. The

specific expansions along with the principle of administrative flexibility to change and expand as our needs and opportunities change would certainly have my wholehearted endorsement.

I thought that it would be useful for me to call attention to two of the several Foundation programs which have the greatest positive impact on undergraduates and which are most helpful now to such administrators as we represent. I believe those have received some emphasis. I might give them a slightly changed one.

I refer first of all to those programs which are directed at the development of new strengths in faculty members, and I would like to make a special comment there. I think we are generally agreed in higher education that quite grave shortages of faculty members are in prospect in the next 10 or 15 years, even for the best of our undergraduate colleges with the highest prestige and for some of the graduate schools and universities. But in all types of institutions, however they are structured, that engage in undergraduate education, I think it is possible that the largest problem within this total problem may be in the numbers and quality of faculty available to teach lower division college courses. High school teachers or individuals with masters of arts in teaching degrees, rather than advanced degrees in subject matter may be called upon increasingly to essentially bear the burden of lower division college teaching, primarily junior colleges and community colleges, but also some 4-year institutions. The Foundation's programs for summer and academic year institutes are aimed at the secondary and college teachers. These efforts could help to meet this problem, particularly when supplemented by the Foundation's programs of curriculum improvement and development.

So I would suggest that consideration be given to even more support for colleges and the universities also, particularly in urban areas, to operate on a fairly sustained and continuing basis faculty programs and curriculum programs for teachers in the community colleges, which has been done in secondary schools. Such running seminars might contribute significantly to the faculty development, having in mind particularly the lower division teaching.

A second program that has been cited already this morning that directly affects our students is the undergraduate research participation program. Reed has had, since its inception, a requirement for all of the seniors of a special thesis based on engagement in research. That senior thesis has involved our students now for 50 years in a particular way of pursuing new knowledge, rather than keeping them primarily in the role of receiving and studying other research.

This same spirit now pervades the Foundation's undergraduate research participation program. We have had a good experience with it and others have already spoken of this this morninng.

I shall try to be specific in several suggestions which have occurred to me that I would like to present, not in a spirit of criticism of the Foundation's program to date, but simply in an attempt to identify some of the things that might be done in the future or with slightly different emphasis.

The first that I would like to suggest is that some of the colleges, as well as the universities, could be, I think, more involved in the task of information transfer from the scientific and academic to the industrial communities and to the general public. Most colleges recognize

a general responsibility to the communities in which they are located, and yet every college may hold a different view of the best manner in which to fulfill that responsibility. It would be possible, I think, for some of them to provide seminars on the latest scientific developments with the audience being the industrial scientists and engineers in this area, so that new knowledge may be more rapidly fused into the industrial sections of the economy. Perhaps these could be patterned after existing seminars for secondary and college teachers.

The Foundation has the responsibility for disseminating results of scientific research. To do so through the undergraduate faculties in this way as well as through the universities would speed the process while providing colleges with support for the very legitimate community service function that would be consistent with their educational role in our society.

Moreover, the liberal arts institutions recognize a future role to educate citizens. The Foundation could support the colleges in education of the general public so that the facts behind public issues involving science might be seen in somewhat better perspective.

Second, it is my understanding that the Foundation is moving toward meeting its share of the large responsibility of the establishment of an overall national science policy by cataloging science activity, particularly that supported by the Federal Government. It is possible at least that a "central bank" of data on Federal research grants and contracts will be developed to assist the rational allocation of scientific expenditures. With some additional effort such information may also be organized in an informative format which would assist college faculty and administration in locating sources of support for local activities, for basic project grants, for facilities, computers, nuclear reactors.

Especially the smaller colleges and perhaps those who have had a little less experience than the colleges represented here today, find it very difficult to have large staffs that are knowledgeable in these areas, and considerable time and effort might here be saved for them if an educator, for example, could come to a central reference catalog and advisory office, which would tell him where to seek support for the particular project that he or his faculty have in mind, what kind and level of support he might expect on the basis of precedents in different agencies, and what projects would be most appropriate for support. The Foundation could play in this way a very helpful role for small colleges by providing an orientation to all Federal science support, reducing frustrations and time spent in determining who deals with what programs in Washington.

Third, as will be the case in the next couple of years, the two present forms of Foundation support for graduate students include fellowships based on selection in national competition, and traineeships awarded by the graduate schools so to speak in internal university competition. It seems to me that it is possible that neither of these forms nor both taken together will fully take advantage of individual judgments by faculty members who work with the budding scientist when he is an undergraduate. Relatively small sums might be placed in the hands of the colleges themselves to be awarded to their graduates on the basis of their confidence in such students suc-

ceeding in graduate school, but whom the other two kinds of competition and support may have overlooked.

As the competition for admission to our best graduate schools inevitably is increasing, the impersonalized screening of applicants, based on grade point average and test scores will also be increasing. There is already some evidence of this. Some young people, and perhaps particularly in some of the sciences, who are quite promising in special fields, have not, during their college careers conformed to the grade-getting race, and can perhaps be identified and encouraged by the colleges who might otherwise be overlooked. I think this should not be a large program, but it might be a supplementary device.

Fourth, like my colleagues, I would hope that the Foundation may continue to expand its use of institutional grants to centers of excellence at the undergraduate level. There is perhaps an analogy to the umbrella grant system which the National Aeronautics and Space Administration has been using, but in this instance the institutional grant might be aimed at fundamental investigations in basic research, rather than mission-oriented research. Aside from the grants for a selected number of institutions which have been suggested as centers of excellence, a larger group doing some research might receive an institutional grant, broad anual support, for related research activities within a college and cutting across departmental lines. This would allow for flexible local determination of areas to be supported, it would help to raise in certain senses the level and style and quality of undergraduate education. It might help to keep more able faculty members in the colleges, rather than in the universities, and particularly might provide younger faculty members with encouragement and support for research at a time when they have not yet established records of publication which allow them to compete successfully for project grants.

One other observation might be in order. It is clear that a number of institutions are undergoing an important process of transition at the present time. The clearest examples may be those colleges, for the most part public, that until recently have been special-purpose teacher-training institutions, have now become 4-year State colleges with liberal arts programs, and in some instances, are moving on to a third stage as regional State institutions.

Another trend is perhaps not so widely known. Some private institutions, colleges of high prestige, are moving already toward adding more research centers and institutes to their programs, and adding gradual instructional programs in limited ways in fields of unusual faculty strength. It seems to me that such changes as this should be viewed with a great deal of encouragement, with flexible means of government support at early stages of these transitions, where that might be one of the better ways of increasing our total national resources of high quality in science research and education. There may be a little bit too much burden of proof on a showing by such colleges that they have already made such transitions before they are technically eligible for certain kinds of support. More and early willingness to encourage well-defined intentions to move in this way might be helpful.

I appreciate this chance to talk with you, Mr. Chairman.

Mr. DADDARIO. Thank you, very much, Dr. Sullivan.

Mr. Roush?

Mr. Roush. I wonder if each member of the panel could give us the basis for the support of your particular college? Is it an independent or a denominational school?

Dr. Atwood?

Dr. Atwood. Emory was started as a Methodist college in 1836. We would classify it today as a church-related university. The total church support is about 1 percent of our $35 million annual operating budget. We are in the same category as Duke and Northwestern and a number of other schools that were started by the Methodist Church, but have moved into this somewhat more remote relationship.

Dr. Dixon. Antioch is nonchurch related, nonuniversity related. It is what is called, I guess, a freestanding liberal arts college.

Dr. McBride. Bryn Mawr was founded by Friends, but not in relation to any meeting. It is an independent college.

Dr. Sawyer. Williams College is an independent college.

Dr. Sullivan. Reed has never had any church relationships. It is independent. Sometimes when I look at our financial problems, I think it might be described as a "free-falling" college, rather than free-standing.

Mr. Roush. Mr. Chairman, the reason I asked that question is I thought I might be a little critical at this point. I am a graduate of a small college, and I can appreciate its problems because for 16 years I have served on the board of trustees of a small college. My wife is a graduate of a small college, and we intend that our son be enrolled in a small college this coming fall. But it seemed to me that this panel, if I sense this correctly, is really not representative of all of the small colleges. There are hundreds, and I suppose thousands of small colleges, which may not have a very close church relationship, such as my own. I gather from what I have heard here this morning that the colleges represented all receive considerable support from the National Science Foundation, and maybe other governmental agencies. They not only receive this support gladly, but are perhaps dependent on it to a certain extent or at least they have a very liberal view toward accepting it.

I live in Indiana. We have, of course, fine universities there, but we also have small colleges, some of which are church related, which are very conservative in their view. Wabash and DePaul are good examples.

In my own district—and nothing could stimulate a Congressman's interest in a small college more than this—I have five small colleges, and they, too, tend to be very conservative in their view.

I wish, Mr. Chairman, that we had one of these colleges represented on this panel so that its president might address himself to the philosophical question involved in the acceptance of Federal aid and dependence on this type of grant.

Now, I don't say that this is my view. I spoke of sitting on the board of a small college; I am the liberal voice on that board. Each time my reelection rolls around, I wonder if they won't still that voice. It happens to be the only extra-curricular activity that I have maintained in the 7 years I have served in the Congress, and I would hope that they do not do that. But I do think if we are to get a well-rounded

view of the problem and the philosophy involved, that we should hear from some of these other people.

Then, too, there are colleges—and I had the president of one speak to me the other day—where the relationship between the National Science Foundation and the college left something to be desired. Probably it was just an administrative problem, yet it was something I feel that the committee should be aware of as it studies the functions of the National Science Foundation.

I might just throw this out in closing: Do members of the panel believe that the reluctance on the part of some of the colleges to participate, say, in the programs of the National Science Foundation is in any way deterring or holding back the progress which we might attain in the area of science?

Dr. Atwood. Mr. Chairman, I would like to call your attention, if you haven't seen it, to the study the Danforth Foundation has conducted recently. The preliminary report covers more than 800 church-related colleges in this country. It is the most extensive study of this kind that has been done. The staff work is still going on. They have had a series of regional seminars with all of the schools involved, at seven or eight locations around the country, and the full study, which will probably be issued during this year, is a book. But it does go into this question, along with lots of others, as to what should be the position of the small church-related college in relation to the acceptance of Federal support.

Coming, as I and Congressman Davis do, from the Bible Belt, I know the feeling that exists in certain of the institutions in our area. There are some of them that have no desire whatsoever to accept any kind of Federal money.

Mr. Roush. In not accepting this Federal money, are they really avoiding some of their responsibility?

Dr. Atwood. It is my personal view that they are.

Dr. Sawyer. Mr. Chairman, if I could comment on this, I would feel for most of the institutions, certainly one I am most familiar with, we are talking about something like 2 to 3 percent of the budget. The amounts are around a hundred thousand dollars from NSF in a college budget, and that is not a situation of dependence.

I believe, as Dr. McBride as indicated, an institution can consciously maintain policies such as paying its own faculty their regular salaries out of its own resources so as not to get into a situation of dependence or that might imperil its freedom of action.

I think some of the large universities, running into 20 to 30 percent of their income, and some of the technical schools have been much higher, have been concerned and have studied this problem.

I think for the small liberal arts college it is a means that does not distort their policies or purposes, but can enable them to do better the job that they are in business to do. I have not seen in any relation with the NSF anything that imperiled our freedom to direct policy and ways we feel are sound.

Mr. Roush. I gather, then, Dr. Sawyer, you are saying that within your experience there is no undue or inappropriate Federal influence on the part of the sponsoring agency?

Dr. Sawyer. To which we have been exposed at the levels at which we are recipients.

Mr. DADDARIO. Your level of participation with the National Science Foundation would probably be less than with some of the private foundations?

Dr. SAWYER. Right.

Mr. DADDARIO. You have that same flexibility I would expect?

Dr. SAWYER. That is right.

Mr. DADDARIO. Dr. Dixon.

Dr. DIXON. I am sensitive to the points which Mr. Roush raises. If a college holds as a matter of principle in its ideololgy a feeling about not dealing with the Federal Government, then there is no way probably to construct relationships which would be helpful there. But some of the concerns I think I have observed in the deeply religious colleges that surround us in Ohio have been the more general concerns of autonomy.

I would suggest that if one pushed a little more toward this institutional grant, which had in no sense coerciveness in it at all, but which says in effect you are a good institution, we accept the evidence that you are good, and we put no strings at all upon the ways in which you shall improve your quality in the sciences, that this would be helpful to some of the small undergraduate colleges that are struggling with this question of Federal relationships.

Mr. DADDARIO. Dr. McBride.

Dr. MCBRIDE. Mr. Chairman, I looked back to the report prepared for you and noted that in 1964 the number of institutions applying under the undergraduate instructional scientific equipment program was 780.

Now that, I should imagine, would be perhaps a third of the institutions that might be qualified to apply, but it is a pretty large number, it seems to me.

Mr. DADDARIO. Dr. Sullivan, doesn't one of your suggestions touch somewhat on this? If there were centers available through which all schools could better understand what was being done, and the degree of autonomy which they would have in the event they would participate, you might get more of them seeking this kind of support? They probably do not seek support because they are fearful of it without having real reason to be.

Dr. SULLIVAN. I think so. I might add this, I feel Mr. Roush's point that we are not directly representative of the generality of small colleges is well taken. On the other hand, I think each of us does have his own relationships in his own backyard with neighboring institutions that do permit us to make some representations.

For example, in Oregon we have the Oregon Colleges Foundation of which most of the private colleges, nearly all of them, are members and an independent college association, which does include all the accredited colleges, and most of those incidentally are denominational institutions unlike Reed.

I would say more than half of those dozen colleges are not in a position—have not had direct experience with grant seeking that has been really very helpful to them. Their staffs are very small, and they are somewhat bewildered in really how to go about the job, what kinds of support are available for them, and I don't sense in that group a hardened determination of any kind not to accept Federal funds under the proper conditions. I am sure there are many conditions under which

they would not and should not accept Federal funds. But we do not have a situation like the one that is quite well known that you have in Indiana. I think that is atypical, it is regarded as such. That may make it even more important.

Mr. DADDARIO. Mr. Mosher.

Mr. MOSHER. Mr. Chairman, in anticipation of these hearings, several weeks ago I wrote to the chairmen of the various science departments in my own college, Oberlin, and asked those chairmen to comment on their relationships with the National Science Foundation. I asked them also to invite some of their faculty people to come in.

I have received a number of letters from these faculty people at Oberlin which contains a complete chorus of applause for the National Science Foundation, and really urging that they have more of the same.

I think that is what we have heard here today. I think that is interesting because today we have heard administrators, and these letters I have are from faculty people, teachers, and they all echo pretty much the same point of view.

I am going to turn those letters over to you and to Phil Yeager on the chance that there is something in there that you might want to include in the report.

I was interested in President Dixon's very forthright confession that there is a certain lack of quality, lack of first-class teaching that is altogether too characteristic in the small colleges. President Sullivan also said something of the same sort. I suspect that this doesn't apply so much to the institutions that are represented here today as it does to some of the hundreds of other small colleges. But it certainly has impressed me that there is a dearth of real quality teaching, particularly as you said, President Dixon, in the physical sciences and increasingly so in the social sciences.

The limited supply is very real, and there is terrific competition with the bigger universities stealing the really good talent. It seems to me the most fruitful emphasis that the National Science Foundation could use in all of its programs is an emphasis on developing better quality teachers and teaching techniques. Of course, NSF has been doing this, but again I say more of the same is necessary.

President Dixon, you have emphasized the need for more effective and intimate relationships between the colleges and the National Science Foundation.

Now it seems to me, since there are so many colleges, to have more effective and intimate relationships, it requires an expansion of the National Science Foundation staff to a considerable degree. As an alternative to that, someone has suggested that the National Science Foundation might under contract to regional groups, college groups, work that way, rather than expanding its own staff. Do you see any advantage in that?

Dr. DIXON. I see advantages probably in both. I think that the notion of expanding the staff of Federal agencies is a fairly usual way at getting at a more complex problem, but the notion of whether or not undergraduate colleges could work together in consortia for the advancement of national policy and accomplishment of science is more novel.

There is the Associated Colleges of the Midwest that have developed a few effective relationships, particularly with large atomic

energy installations, with the Argonne Laboratory, and have joined together in certain fields of biology.

Mr. MOSHER. Antioch belongs to a new association?

Dr. DIXON. Antioch and Oberlin belong to the Great Lakes Colleges Association. We have had with the advice and assistance of the National Science Foundation, one exploration in this consortium of what we might do as a consortium that we could not do as individual institutions.

There seems to be two things we can do. As a consortium we could manage much more efficiently with the National Science Foundation on many of these internship programs. It would lend real economy and efficiency to the method of selection and support. And as a consortium we could, if we would waive our own sovereignties and recognize at any point of time that Oberlin might have the superior physics and Antioch the superior biology, we could ask the National Science Foundation to provide mobility to students that would permit them to move from campus to campus where we agreed that the programs had special elegance and need.

Mr. MOSHER. One other practical question, Mr. Chairman.

I believe one of the services that the National Science Foundation provides to the small colleges is helping to finance the purchase of the more sophisticated equipment and tools for scientific research.

As you increase your equipment and sophisticated tools, do you have a problem in the small college of hiring the technicians to keep those tools in operation? Is this becoming a practical problem at all?

I should think to make the best and most constant use of sophisticated machinery you might find it difficult to hire the technicians, in fact just cost of hiring technicians might become burdensome. Have any of you had that problem?

Dr. MCBRIDE. That is a very clear problem. That is one of the problems which ends in the college budget's increasing.

Mr. MOSHER. As a trustee of Oberlin this is the point I make.

Dr. DIXON. In response to this need one of the things which we do which is not necessarily decent in terms of education is to use undergraduates as technicians in the context of undergraduate research.

Mr. MOSHER. Is this a problem that NSF should give more consideration to and possibly help with?

Dr. MCBRIDE. I would put first some increase in some of the very good programs which are not large enough to go around—the instructional equipment program itself, the undergraduate research participation program. I think that comes first to my mind.

Mr. DADDARIO. Do you have a comment, Dr. Sullivan?

Dr. SULLIVAN. I just wanted to pick up one other aspect of the equipment program since it has been brought up.

For the undergraduate instructional equipment program, these grants are now on a 50-percent matching basis, that is, they provide 50 percent of the cost. There is a kind of competition within a college budget that arises from this. The cost of a piece of equipment that is purchased under a faculty project research grant may be paid for a hundred percent, it may also be useful for instruction, but the department and the college that asks for the instructional equipment for undergraduate work get a 50-percent grant.

Now it is very difficult to say, "No, we won't apply for that grant," it is a very attractive carrot, so to speak, but it does mean that the unrestricted funds of the college must be diverted in some cases.

Occasionally a special gift from a corporation or an individual will result from this carrot. But frequently, and as a continuing program, it is much more likely it will be a burden on the unrestricted funds of the colleges which are in very short supply. I think this might be given somewhat more attention also, as well as the cost of operating and maintaining equipment.

Dr. SAWYER. I would agree, Mr. Chairman, that Mr. Mosher has put his finger on a very real overhead cost that comes with the sophistication of science today, and, as we acquire this equipment, we are finding that we have to plan for technical help. It may be met through arrangements such as Dr. Sullivan spoke of where, by a relationship with industry in the area, there can be some helpful sharing of that cost, or by a moonlighting job arrangement with a technician there. But it is a cost, and I think it is the kind of help that the more generalized institutional grant that Dr. Dixon referred to could help institutions responsibly cope with.

Mr. DADDARIO. Dr. Dixon.

Dr. DIXON. I think this is related to this point. We have had some experience in the last few months in working with one of the so-called centers of excellence grants, and it is interesting to see what happens when you take an institution that tends to want to declare itself such as ours as being reasonably excellent and then ask the people of that institution what they would do to measure up to their own standard of quality. This is an internalized test. This isn't a test of having the university look at the undergraduate institution and saying what you would do.

Really it is staggering to those of us who administer the institutions to see what our faculties, who regard themselves as modest, would think it is necessary to have to produce undergraduate education in the sciences and social sciences in our time. I think they must be in considerable measure right, because after all they are the colleagues in the disciplines that set the standards.

If that is the case, our resources are vastly less than they should be to sustain this support. This runs through the whole gamut, this is physical facilities, this is supporting personnel, this is the teaching of teachers, this is the time for faculty research, this is the incorporation of undergraduate research into the undergraduate program.

Dr. SULLIVAN. And the library program.

Dr. DIXON. Yes.

I don't think I was wholly honest in response to your earlier question about regionalization—and if you let me use this private institutional experience to make my point—the genuine fear, I think, and it is a fear, that many existing liberal arts colleges have about regionalization is that this will increase specialization in the sciences and the social sciences as we move along in the social sciences, and will no longer permit good students to nominate themselves as students to the existing liberal arts colleges.

The fear is that when you confront this situation, as we are trying to confront it in the centers of excellence program, we will soon know the

gap is very great and we know if we were actually going to sustain this climate of wholeness that very significant expenditures must be made so that the status of the teacher in the liberal arts college who decides to teach physics in the liberal arts college as opposed to being a basic researcher in physics in the university is sufficiently strong, and he sees that that is importantly appropriate.

Our reason is not just a selfish reason, we want him to be capable— not just a social reason, it is simply that you cannot teach the humanities without the sciences, and you cannot teach the social sciences without the humanities.

If public policy is such as to draw away elegance of one group of disciplines in the national interest, it will, in effect, collapse the historic role of the liberal arts college. I think that needs to be said when one speaks about concern for regionalization.

Mr. DADDARIO. Mr. Mosher has underlined again the concern which has threaded itself throughout these hearings: It is much easier to come to a determination about quantity rather than quality, and the future quality will be extremely important. The denial of facilities such as these that have been raised by Mr. Mosher's question can seriously affect the quality we will have in the future.

It was mentioned yesterday that if we are to increase our research and development role to the point where it will be 4 percent of the gross national product as against the 3 percent today, it would mean an increase from $16 to $37 billion. We are going to need a lot of people of high quality to perform these functions.

Mr. MOSHER. I wonder if President Dixon is aware of the interest in the Congress for the creation of the National Humanities Foundation?

Dr. DIXON. Yes. And if history were to follow itself, it would put a further penalty on the liberal arts colleges by emphasizing first the quality of scholarship in the university and then second the quality of education in the liberal arts college.

Mr. DADDARIO. Mr. Davis.

Mr. DAVIS. Mr. Chairman, first I want to say that I think Dr. Atwood chose a particularly happy way of transferring his thought to the committee by selecting specific examples of boys who have become real specialists and who might well have been overlooked had it not been for the presence of Emory University in Georgia, and had it not been for the help of the National Science Foundation.

It happens that one of the boys you named is a constituent of mine, his father is a very old friend of mine. It proves that we have in all areas of our country the mental resources that we can't very well do without. We need resources, and we need to be assured that university facilities are available, and that these fine minds can be exposed to situations that will lead them to become specialists and to use those minds. I am glad you chose to give those examples for that reason.

There is one thing I wonder about. The point was made that in order to disseminate new scientific discoveries to the industrial sector, it would be a good idea to have seminars. I wonder if it wouldn't also be a good idea to have seminars between the large universities and the small ones, between the faculty members. Do you do such things as that, say, in Georgia, Dr. Atwood? Does Emory have seminars with the faculties of such colleges as Barry and Shorter?

Dr. ATWOOD. There is a rather specific answer to that in the case of our physics department. This is a participation program that involves contact with the secondary schools in the area. It is sponsored by the American Association of Physics Teachers for the State of Georgia. Professor Simons in our physics department is councilor for this, and through his efforts, working with the faculties of other colleges in the area, various high schools throughout the State are involved under a joint program. This had NSF support. New teaching methods in courses are part of it.

This kind of effort involves interuniversity support in a very significant way. I am sure you are familiar with the University Center in Georgia concept. It operates mainly in the Metropolitan Atlanta area. Again there are geographical limits as to how far we can go with this, but we are certainly pooling our resources wherever we can in this regard.

Mr. DADDARIO. Do you have a comment on that, Dr. Sullivan?

Dr. SULLIVAN. I tried to suggest both things. I think we can do somewhat more. In the past the main thrust of the institutes managed by many of our colleges, as well as the universities, has been toward improvement and upgrading of the secondary school teachers, but on occasion we have had two institutes during the summer for college teachers, one primarily in physics and another in inorganic chemistry, and the former was directed specifically at the college teachers in teacher training programs, for example, who had had a necessary minimum but still a minimum of direct science courses in their own training and are now ending up as science teachers, and I think a good deal more can be done in this way.

I think the help of a national organization like the Foundation would be very real in this respect. I think many of our faculty members are quite modest about putting themselves forward as capable of teaching all the other colleagues in the same discipline in neighboring colleges, but this can be overcome.

Mr. DAVIS. The following statement is in some material that the committee staff has prepared:

> Considering the urgent need for more technicians to improve the utilization of scientists and engineers, it may be desirable for small colleges to focus their funds and faculty on subprofessional training.

I do not mean to dwell unnecessarily on the State of Georgia, but it happens to have the educational system I am most familiar with. In my district there is a school known as Southern Tech. It is near Marietta, Ga., and its charter is to train technicians of subprofessional quality. I am unaware whether that approach is being used in other States or not, but I am sure that Dr. Atwood is familiar with that school.

Would you say that such a program is a threat to the future of small colleges or is it a welcome adjunct?

Dr. ATWOOD. It is a welcome adjunct in that most of us are not equipped to do it, nor does the faculty temperament want to do it. It is a different kind of a job, and it can be done best in an institution that is set up to do it.

The same kind of problem comes in the paramedical need that is being talked about so much in the country today. We are probably going to need specialized institutions to do that kind of training.

This in a way reflects back on the earlier comments of Congressman Roush when he accused us of not being typical, and I think we all accept that. I don't know how you quite can have five schools out of the hundreds of liberal arts colleges and get a true cross-section. I would say in effect we are a measure of the kind of sophistication that you can promote in the small liberal arts colleges. Most of us, in our modesty, would say that perhaps we are somewhat above the average, and in that sense we aren't typical. Part of the job of higher education in this country is to raise that average. Part of the reason that other schools have not taken advantage of the grants is indeed this degree of excellence, this degree of sophistication.

It is not a problem within my own institution. The total Federal funds that were available this last fiscal year amounted to nearly $6 million in our institution. It is true that a large percentage was for medicine and its research program, primarily from HEW. Our NSF funds amount to more than a third of a million. The reluctance of some schools to engage in this kind of effort is related to their lack of acquaintance with what is available and how that can help. That is not the problem among these five institutions, but it is a problem elsewhere.

Mr. DADDARIO. Dr. McBride?

Dr. MCBRIDE. In relation to Mr. Davis' question about technicians, I simply wanted to note that it was not only the specialized institution that Mr. Atwood mentioned that was going to work on this problem but the community college. In States in which community colleges are developing there are included in their broad programs a number of specialized programs for technicians.

Mr. DAVIS. Mr. Chairman, I have one final question.

In dealing with the National Science Foundation, do you find that you can live with the formula for the limitation of overhead, or do you have continuing problems in that area?

Dr. MCBRIDE. It is just like the weather, Mr. Chairman. We can live with it.

Mr. DAVIS. But you don't always enjoy it?

Dr. MCBRIDE. It is not entirely satisfactory.

Dr. SAWYER. To comment on that, I know some of the bigger institutions that have studied their costs more carefully put a much higher figure on overhead. As Miss McBride says, we live with this because it is helpful.

The overhead, including the visible kind of thing that Mr. Mosher spoke of, providing technical assistance, space needs, et cetera, as well as direct costs, clearly exceed the allowed overhead.

Mr. DADDARIO. Congress has taken action to eliminate this section in the appropriation acts. I think there will be an improvement, and we are anxious to see how the new legislative changes will affect this relationship. We hope it will allow for better flexibility and a better relationship.

Dr. SULLIVAN. I hope this can be pushed ahead in this Congress. Like the others, what we receive is inadequate, but it is better than not receiving any at all.

Mr. DADDARIO. The House Appropriations Committee has already taken steps in this direction. It is my understanding that the Senate

will follow suit. So we should have a different relationship, and one which I hope will be an improvement.

Mr. DAVIS. It was brought out by Dr. Wiesner, and it has been mentioned more than once this morning, that there exists a very bad need for computers. Does that mean that computers have turned out to be a tool with which the scientists find they can make much more rapid progress? Is that the meaning of the word "need" in that connection?

I ask this question because 18 years ago no one had ever heard of a computer.

Dr. MCBRIDE. There are two tremendous changes. One is in the range of problems that the scientist couldn't study at all if the computer hadn't existed. And two, there are ranges of problems that scientists won't have studied because they would have taken too much time. So the rapid advance of certain fields of science and certain fields not involved in sciences is one of the factors of present-day life. I think that the efforts made by several groups to estimate the future for computers are very important estimates.

Mr. DAVIS. Thank you.

Dr. SULLIVAN. I think I could add one or two points. One, I think there is a growing feeling on the part of many faculty members in science that not only their somehow personalized students majoring in science, but the generality of students in college, should become at least somewhat familiar with this new language as a problem that they are going to have as citizens.

And, secondly, I think in the hands of some faculty members, at least, this is not only helpful for research and for dealing with new problems, but it can be a fairly exciting tool for instruction, not only with college students, but we have had this experience this summer with a group of high school youngsters we are experimenting with on the campus.

Mr. DADDARIO. It has come to my attention that Vassar has arranged with IBM to use a computer at Schenectady during certain hours. I imagine thought has been given to this so that schools can get together and make arrangements to use computers in some form or another which will suit their needs.

Dr. SULLIVAN. This has been done quite rightly. Particularly for dealing with research programs, we are members of the Western Data Processing Center. But having some computer facilities on the campuses of these colleges also does something quite different in the direction of instruction—what you don't get quite over the telephone from Los Angeles to Portland, Oreg.

Mr. DADDARIO. Yesterday Dr. Wiesner brought out the point that computers, being so important, being such a tool to aid the quality of education, that the denial of their use could have a great effect. So I do agree, Dr. McBride, that the studies being made in this regard and how they can be used will be extremely important.

Mr. Brown?

Mr. BROWN. There has been during the course of these hearings considerable discussion with regard to balancing the program of the National Science Foundation insofar as relative support of the physical versus the social or environmental science. There seems to be no

question that the Foundation, as originally set up, had its primary emphasis in the physical sciences. There is a growing trend toward support of the social sciences. After all, they are still sciences. The question I would like to ask the panel is whether or not there needs to be an increasing attention to the support of basic research in the social and environmental sciences. I use this term in a broad sense.

Mr. DADDARIO. Would you like to start that off, Dr. Dixon?

Dr. DIXON. Yes, Mr. Chairman. It is a terribly complicated question, I think, because it carries in it all of this loading of relating the sciences and physical sciences to the social sciences and science. I suppose one of the ways to get at it would be to look at what a faculty in the social sciences would do with opportunity to extend their concerns, and one gets the impression that the social sciences are struggling not only with basic research, but they are struggling once again with what you would call applied research.

Anthropologists have begun to discover that we have also a contemporary culture, for instance, so that this can be studied. Contemporary data is being studied by the economists. So I think it is very hard in the social sciences to make this basic versus applied comparison. What social scientists seem to think they need are opportunities to invite young scholars at the undergraduate level into research, however defined, opportunities for support of their own scholarly objectives, however defined. And the one place where they seem to join with the physical science is on the question of hardware, on the point of computers that we were just discussing. They, too, want high capability for the analysis of random events as an element of their approach to basic research.

Mr. BROWN. We are talking about more than hardware, we are talking about fellowships, traineeships, faculty salary support, physical facility support—the whole range of NSF programs.

Dr. DIXON. There is one straw in the wind, and this must surely have come before this committee, and that is the effect that the changes in education in the sciences and social sciences now going on in the secondary schools are going to have on the undergraduates' education. This is now being seen, obviously, in mathematics, physics, biology—would not you say? We have not seen the emphasis of the changes in the social sciences at the secondary levels, which is going to make a very drastic change of the undergraduate curriculum in the social sciences, and is likely to step up the demands for support in undergraduate research, for instance, the social sciences at the undergraduate level.

Dr. SULLIVAN. And in college curriculum in these fields.

Dr. DIXON. And in college curriculum research in these fields.

Mr. BROWN. You haven't really hit the question head on, but let us continue. Maybe we will get some further suggestions.

The question, head on, is: Do you want to work in the direction of a program of an increasing level of support in these fields which are not getting the major attention at the present time by the National Science Foundation?

Dr. SULLIVAN. My answer to that would be that I think we should. I think there are two pitfalls. One is when asked a question like this, you are being asked either what proportion of additional support coming from the Foundation should go into this, or whether allocation

of present levels of support should be changed more in favor of the social sciences.

Mr. BROWN. Let me broaden the question. Really, we do not have to confine ourselves to the National Science Foundation. In the growth of the Federal support for education, we first had organizations such as the National Institutes of Health, in the health sciences, and much more recently the National Science Foundation aimed primarily at the physical sciences, but not entirely. We now have before this Congress a bill for an Arts and Humanities Foundation. Perhaps there is trend here for another foundation that would deal with the social and environmental sciences.

Dr. SULLIVAN. It surely is my general feeling that the social sciences have been starved, in this respect, in favor of the hard sciences—mathematics, physics, the health sciences, so I would welcome moves in this direction. And I think my own preference would be—and I am speaking highly personally—would be to continue this at least for a time within the National Science Foundation, rather than to move now to set up a separate agency for that purpose.

There is a second pitfall which I wanted to mention very briefly—and Dr. Sawyer is much better qualified on this than I am—and might conceivably disagree with me—but I think there is a tendency, I believe there is a view shared by some social scientists, that research and other activities in these fields would be most likely to receive support insofar as it essentially deals with highly quantifiable things, measurable things, and much of the most thoughtful research in these fields is not really of that character. I think that is generally the case. It is my impression, at least, that the philosophical kind of what I would still regard as research in these fields is especially undernourished and unlikely to receive support as much as the data collecting research will receive.

Mr. DADDARIO. Dr. Sawyer?

Dr. SAWYER. First, I think Mr. Brown's question is a good one, here, and in the long run I would guess there would probably be a case for increasing NSF or other funds in this area. But I think you have before you here, as representative in one sense of the colleges of the land, five battle-scarred veterans who are trying to meet science budgets that have risen sharply. The overhead costs for serious social science research are much lower. Some edges of it are needing computer time and similar things. The plant requirements and the technical requirements are typically less. They have also had a pretty good measure of private foundation support. It may be that private foundations will be less able to supply the need in the future.

In the area of social sciences, there are a lot more problematical issues, sensitive in terms of human reactions and emotional reactions. There might be more restraints on the freedom of such grants as to subject matter and directions of inquiry. If they were to be made, I think they ought to be in a form that was carefully devised, not to limit subject matter, either as an institutional grant——

Mr. BROWN. You are bringing up the political problems, which basically are the concern of the Congress, including the Federal role or presence in any field of education. It is a serious one. One needs to seriously consider it.

I am thinking in terms of the needs of the country as a whole, and not just the admitted large cost of research in the physical sciences. There is this whole problem of support for the graduate students, which is the same, both for the physical and the social science.

Dr. SAWYER. I think it is a question of the form. Very clearly looking ahead, not only are there needs for teacher training, for graduate fellowships, the kinds of institutes and summer programs that have been run here, but as somebody said, we know more about the molecule in outer space than we do about the social world we are living in, and very clearly a farsighted policy should anticipate increasing need of research funds for the social sciences.

Dr. ATWOOD. Perhaps it could be said that the colleges and the universities are more nearly competitive in the social sciences than they are in the physical sciences. This would lead me to second the comment made by President Sullivan that it would seem highly desirable for additional Federal support for social sciences to be made available through the National Science Foundation. This would probably tend to make such grants more the institutional type, rather than mission-oriented sorts that would come through a separate new agency that would, just by virtue of its being an institute of social sciences or a foundation of the social sciences, probably want to get problems solved.

Dr. DIXON. Now that you have opened the question, may I return, as there are one or two specific comments that I think one can make. The pressure in our kinds of colleges for the recruitment of the faculty in the social sciences is not as great as in the physical sciences. I think that can be stated, although it must be said at the same time that Dr. Sawyer's discipline, economics, is one of the scarcest of all disciplines—is one of the least reproductive, I might say, of all the disciplines. There are evidences of selective shortages in the social sciences, as there is in the physical sciences, but not at the same level. I think that is a clear fact.

Mr. BROWN. Isn't it true that to a very large extent this shortage in the physical sciences is one actually created by the Federal Government itself because of its support of the physical sciences in defense and atomic energy?

Dr. DIXON. I am not quite sure. Against that is the counterargument, which I might be permitted to use because my own field was medicine, the counterargument is the professionalism of the discipline that makes the difference. If you look at the physical sciences they are themselves trapped into a hierarchy of steps of training. You must move through this pattern for a long period of time in order to get through the profession. So it is not just the question of Federal research support making the competitive opportunity, but it is also the question of the professional behavior of disciplines in closing the entry to a discipline, and therefore holding the supply down.

Social sciences do far much less of this than the physical sciences, and the humanities do the least of all in terms of restricting entry.

Dr. SULLIVAN. On the other hand, sir, isn't there a good deal more concern about the number of years that the Ph. D. program is taking, first in the social sciences and secondly in the field of humanities, than is now true in the sciences? I think this support of the kind you are mentioning might help this problem.

Dr. DIXON. Do you think it might narrow the problem?

Dr. SULLIVAN. I think several things have worked on speeding this up in the sciences. One is the virtual availability of much more graduate fellowships, and the second has been the urgency of curriculum development, which has exerted its own pressure.

Mr. BROWN. I want to raise the philosophical problem here, not that Congress normally deals too much in philosophical problems, but the orientation of our society is unquestionably one of technology and physical science. This has resulted in the vast increase in GNP, and a vast widening of the gap technologically speaking between the advanced countries and the underdeveloped countries. This is a characteristic of our society.

However, I think we can raise the question, Is it necessarily a good characteristic? Perhaps we should be devoting our time and attention to this question of the quality of our culture in a broad sense, rather than merely the improvement of technology which is the basic thing that we are doing with the support of physical science?

Mr. DAVIS. Will the gentleman yield on that?

Mr. BROWN. Yes.

Mr. DAVIS. The problem that always strikes me about the social sciences is this: My colleague, Mr. Brown, just used the word "quality." It seems to me, you trap yourself quickly in the social sciences because it is so hard to keep from dealing in therepy as distinguished from basic research. Basic research assumes that you do not care what it is you find out, or what the result it. If you use a word like "quality," you automatically pigeonhole your research into either good or bad, and once you have done that you have prejudiced your efforts so much that it is no longer science.

This is what bothers me about the social sciences. For one thing, I don't know how you tell a good social scientist from a bad one.

Mr. BROWN. The question you raise is one of values, and I think it is only fair to point out that this is the most delicate the Congress can deal with. I personally feel we are on the verge of having a great deal of insight into the way human beings function in communities, insight that could be developed rapidly, that could be applied systematically, that could be contributory to the enhancement of human life. I am thinking not only in terms of the United States, but on a worldwide basis. It might be the most significant weapon that this country can have in terms of its role in the world, much more significant than another few billion dollars worth of atom bombs, for example.

If this is true, then we are neglecting the national interest in not furthering this.

Mr. DAVIS. I would agree with that.

Mr. DADDARIO. Any comment?

Dr. SULLIVAN. Applause.

Dr. SAWYER. Applause. I think that is right. I think the sense of the gap of our capacity to cope with this world and what we should reach for is most clearly visible in the sector you are talking about.

Dr. DIXON. Again, applause. It is a hard question to put to educators who say they are educating for the humane society—as to whether or not one gets at peace through mathematics or economics or whether one gets at peace through physics or anthropology. But

I would suppose there is only one answer, if the hypothesis is sound. there is only one way to discover whether it has any meaning; and that is try it. Beyond the point of speculation, it seems to me, one cannot get, unless one tries it.

Mr. BROWN. I think perhaps we have explored the problem enough, Mr. Chairman.

Mr. DADDARIO. It is always good to end on a note of applause, Mr. Brown.

Mr. BROWN. I suppose.

Mr. DADDARIO. Mr. Conable?

Mr. CONABLE. I think there is a certain amount of pessimism implicit in the democratic process, and we are in an area that we could talk all day about, our ability as a democracy to instill this kind of value.

Let's come to something more specific. I am concerned about the mechanics of your contacts with the National Science Foundation. Apparently there are a number of schools which are not having a very extensive or very happy relationship with the National Science Foundation.

I assume that most of you have had, for the most part, fruitful contact with the National Science Foundation and, therefore, you are not inclined to be critical of the administration of the National Science Foundation. The administration does become a matter of substance on occasion.

I wonder if you have any specific suggestions on ways in which the National Science Foundation can reach out to include a greater part of the colleges in the country. I am concerned with their relationship to colleges and universities, of course, and not anything else. This is something perhaps we are going to get into, Mr. Chairman, but I would like to get the reaction of this group on this specific question.

For instance, does NSF come to you, or do you go to them? If they do not come to you, should they?

Mr. DADDARIO. Dr. Atwood?

Dr. ATWOOD. We have touched on this and perhaps we could stress it by saying that it ought to be more of a two-way street. Now everybody is coming to Washington and being the supplicant. It would be a better stature, a better position, if the Federal Government were in part selling its wares, if it were out looking for good customers. This might be done by the establishment of regional educational offices of the Foundation.

Mr. DADDARIO. Following Dr. Sullivan's observation?

Dr. ATWOOD. Yes; a man in an area becomes the knowledge man, the contact man, the source of information about the Foundation, making it more accessible. Such regional representatives could assist with the difficult problem of allocating, to be sure that you do have not just a few proposals before you that happen to have been there but rather all the proposals that might possibly come from any source.

Mr. CONABLE. It is a matter of your coming to Washington generally?

Dr. ATWOOD. We commute.

Dr. SAWYER. If I could pick up this comment, I would feel that the problem was in some sense less NSF than the total Federal structure.

I think where the small college feels lost most often is where else might it have applied or where parallel programs might be submitted.

Most of us know about NSF and NIH, but then someone will mention the real place for this is over in HEW. Here we are not knowledgeable, at least very few of us are.

I thought the suggestion that Dr. Sullivan made was good—a possible central roster and information office, possibly then with regional offices, where you could come with your problem or area of interest and you could find where the various programs in the total Federal establishment might be sources of support.

Mr. Conable. I assume all of you also deal with other Federal agencies. Are your relations with the National Science Foundation as felicitous as they might be with the other agencies, or do the other agencies handle their contacts with the universities in a different way?

Dr. Sullivan. I think there is some variety of this kind. I would myself think our experience in this respect with the National Science Foundation is probably at the top of the list.

Mr. Conable. That is the sort of thing I am interested in hearing. We are, of course, studying the National Science Foundation.

Dr. Sullivan. Not to subtract from my earlier suggestion, my own impression is the National Science Foundation has done a pretty good job of informing the colleges of what its own programs are, not only by publications but also by field visits and by regional conferences. I know we have played host to a couple of these where neighboring colleges send faculty members to a conference that was of an informational character. So my suggestion stems from the increasingly complex problem of all the agencies overlapping more from than any criticism of the job that NSF has done by itself.

Mr. Conable. This is not a problem that is peculiar to universities I might add. Almost everyone who deals with the Government seems to have this sort of problem.

Dr. Dixon. I would add to what Mr. Sullivan has said and say this, in the range of Federal agencies with which the small colleges deal, the National Science Foundation seems to have a much greater appreciation of the context of getting at science within the organized setting of education and places an emphasis on the relevancy of the context without I think denying the importance of the discipline. Whereas many agencies put the emphasis on the discipline to be served whether or not it distorts the context in which the service is given. We regard this as of course very creative administration.

Mr. Conable. I would like to ask one more question.

In relation to teacher training, which is an area of major concern, do you have any suggestions beyond expansion of the internship program generally?

The National Science Foundation has a very successful teacher institute program with respect to the high school teachers. It has reached a great many high school faculties and has apparently had a noticeable effect on the quality of the instruction of high school students in the physical sciences. These students are entering colleges now, and it is all going for naught unless, having had their interest stimulated, their needs can be met on the college level. So this is a matter of concern in the National Science Foundation I am sure. I

would like to have further ideas you might have about the specifics of a program to instruct teachers for colleges and universities.

Dr. ATWOOD. If you asked a sampling of educators across the country what was the most valuable program of the National Science Foundation, you would probably find there is quite a consensus that it has been the teacher training program.

This is because of the profound upgrading that we have all seen in science and mathematics training in large numbers of high schools, high schools that we had thought were almost beyond recall, or needed such drastic help. It has been brought about very rapidly and on a very wide scale.

The reason we can say this is because this has such long-range effects on development of science throughout the country. It is the feeding mechanism, and we can see the next wave of this coming in terms of a thrust forward that could not have come in any other way.

Mr. DADDARIO. Any other comment?

Dr. SULLIVAN. I might add one quite speculative sort of thing. I don't at the moment see what part the Science Foundation should play in this, but we have recently been through a long debate of a couple of years on the extent to which our college should move further into graduate work.

In the course of that we invited as consultants several people from the universities who had the characteristics of having had experience at the undergraduate level but who now were primarily concerned with the administration of graduate school departments. And one of the suggestions we received from them, more than once, was that a new kind of graduate degree that would have the respectability of a Ph. D. but not as much emphasis on individualized research competence, as usually is the case in this degree, is very badly needed.

It is now the case that we have this one degree in our fields of knowledge, it does emphasize research, it purports to predict that the holder of that degree will engage in research, when we know that a good many of them become much more teachers than researchers.

Some change was recommended in these several cases. I would be out of order to try to give very much of a personal judgment on their suggestion because we don't have that kind of experience. It was an intriguing suggestion. I was interested that it came to us, for example, from both the head of a biology department in a university and the head of a romance languages department in a university.

Dr. DIXON. There is probably a range of novel relationships between undergraduate colleges of the sort represented here and universities that could perhaps be used to construct novel Ph. D. programs of the sort that Dr. Sullivan is talking about that would make the recruitment of teachers more practical.

You asked directly I think whether there was a need for the upgrading of college teachers in the sciences.

Mr. CONABLE. I am assuming there is.

Dr. DIXON. I expect this is so. I expect in the hierarchy of the institutions we have to ask the universities to do it for the colleges in the same sense that we ask the colleges to do it for the secondary schools.

Dr. MCBRIDE. Mr. Chairman, Mr. Conable's question, though raises another point, and an important one. The young teacher well

prepared by his graduate work who then goes to a college will not keep up his enthusiasm and competence unless he has some possibility for further research in the college where he is teaching. So that one of the important programs would be one which would help the young research man who has very little as yet to show for his work but has sufficiently strong recommendations, so that it is worth giving him a start.

Mr. DADDARIO. Any further comment?

Mr. CONABLE. No.

Mr. DADDARIO. Dr. Sullivan, in your preliminary remarks you referred to the fact that Congress has in the case of the National Science Foundation provided an administrative flexibility which you think is both unusual and good, and you favor it. You have said where restrictions exist you oppose them. What do you have in mind?

Dr. SULLIVAN. One we have already discussed a little bit, that is the State quota for fellowships. I think that is undesirable, as I mentioned earlier.

Another, as I understand it, is a provision that a certain amount of dollars or a proportion of the total budget, as the case may be, must go into certain programs or a collection of certain programs. This again limits the flexibility of the Foundation.

I believe that restriction has applied most recently—that kind of restriction—to provision that a minimum amount of funds and quite a large percentage of the total budget should go into secondary—particularly secondary school teacher training programs. If the Foundation did not have this restriction, it and its advisory committees together might reach somewhat different conclusions—a little less might go there or a little more into another sector as needs change. These kinds of restrictions on the freedom of the best judgment professionally that can be brought to bear is what I had in mind.

Mr. DADDARIO. This brings out the point which Mr. Roush raised, that by having this flexibility, you have less central control and more autonomy within the schools, and it makes the National Science Foundation's program more attractive.

Dr. SULLIVAN. Whether that is a guaranteed result or not, it is at least more probable.

Mr. DADDARIO. Dr. Sullivan, you said that you consider the biggest problem to be in the area of teaching the undergraduates. Would you expand upon that?

Dr. SULLIVAN. I think when you group together the problems of quality and quantity it is pretty clear that the institutions most favorably situated to compete for, to attract, and retain the best prospective—not only the present but the prospective—teachers and researchers in science are the graduate schools and universities, where there are lower teaching loads and more chance to be a scientist per se rather than a teacher of science.

Second, I think some institutions like those represented here that have acquired some prestige, that have a certain hospitableness for research combined with undergraduate teaching will be able to attract and retain some faculty members that perhaps other institutions would not.

You get down lower on the totem pole, when you think of the job to be done at a level of college teaching which is in the introduc-

tory years, roughly the first 2 years. Because where this is the emphasis the teacher does not have, even if he likes that kind of work, the additional and important satisfaction of working with somewhat more advanced students.

From the point of view of attracting the ablest scientists and retaining them, this is lowest on the totem pole, I think. It is also the need when you move from quality to quantity which quantitatively is the most haunting one, because the freedom of movement from the high schools into our total collection of collegiate institutions, including an increasing number of juniors and community colleges, is much the greatest there.

Much larger numbers are entering the first and second years of our total collegiate structure than are entering the third and fourth years. So, again, the number of teachers required is very considerable, and it is the combination of the qualitative attractions and the quantitative problem that made me select that particular group of teachers.

Dr. SAWYER. Mr. Chairman, there is one restriction which was implicit in a good deal of our comment this morning, and that is I think NSF is constrained on the amount of funds that it has available for science in the undergraduate college.

There are certain programs with ceilings on them, equipment and research participation and direct grants, for instance, for physical plant and equipment are limited, and I think the need is pressing very strongly at those limits.

Mr. DADDARIO. You raised the specific point in regard to a program that was turned down because of lack of funds.

Dr. SAWYER. A new science center which had had an encouraging reception by the staff. Then the Congress a year or so ago had to reduce the amount available for new programs, requiring NSF to stay with existing programs, and one of the new programs had been a program for assistance in the construction of undergraduate facilities.

If your question had that wide a swing, I wanted to enter that thought.

Mr. DADDARIO. I wondered if Dr. Sullivan's remarks were wide enough to cover programs such as that. I think you indicate that you do include such programs.

Dr. SULLIVAN. Yes.

Mr. DADDARIO. Mr. Vivian.

Mr. VIVIAN. I have one question relating specifically to the NSF relationship to small colleges, and then I would like to switch to a somewhat different subject.

Reference was made earlier by Dr. Dixon to one of the several midwest associations. Would you identify it again?

Dr. DIXON. One is the Associated Colleges of the Midwest and the other is the Great Lakes Colleges Association.

Mr. VIVIAN. There is a third one which is primarily active among the Big Ten schools.

Dr. DIXON. There are others I am sure.

Mr. VIVIAN. I would like to ask you the following question: Suppose that the National Science Foundation had available to it a certain quantity of funds which could be given to regional organizations of small schools, do you think that organization would have difficulty in deciding within itself a simple allocation?

Dr. DIXON. May I answer directly—but I will have to answer by analogy, because we have not had the experience in science. We have had the experience in the humanities and in the social sciences under the auspices of private foundation grants which were designed to encourage exploration in non-Western cultures. These are, in a sense, coercive grants that are designed to make you perform in a way you are not performing.

My direct knowledge of the work of the Great Lakes College Association is this has worked superbly, that they have invented new ways by which to arrive at their decisions, they have invented new ways by which the faculties may join in making these delicate judgments of quality, because this program also includes the expenditure of moneys for research, and they have laid themselves open to the institutional changes that come from the expenditure of money.

So I think the answer would be there is some experience that indicates that if these associations could be granted some of the autonomies of subfoundations—if you want to put it in those terms—they could make some creative explorations of policy.

Mr. VIVIAN. I bring up the question for two reasons: The first reason reflects on a question I raised the other day with the head of a science department of one of our great universities, and a very, very competent man, and I was asking him about the question of distribution and the amount of funds which he had in his department from various sources. It turns out that most of these funds are Defense Department funds. I indicated that we were considering the question as to whether a larger fraction, approaching one-half of the total support for science in the universities, might not well come from the National Science Foundation, rather than one-eighth as it does now.

He was somewhat reluctant to see this because he felt within his own department that stresses and antagonism would arise, which now are handled by each faculty member going to Washington and soliciting the interest in the large bureaucracies here.

Do you think the situation prevails in the smaller colleges?

Dr. DIXON. Certainly not with the same intensities. The sense of allegiance of the faculty member to the institution rather than his discipline is greater in the small college than in the university. The opportunity to undertake change on a collegewide basis is greater.

Mr. VIVIAN. Supposing, for example, the National Science Foundation had, say, $30 million available for regional organizations of the smaller colleges, and this was divided in some equitable way across the United States. Then the question was asked of the presidents of all the colleges in the areas, would you prefer that we administer this from Washington or would you prefer that we administer this through regional compacts of the colleges themselves? What do you think the comments would be?

Dr. DIXON. I think it would vary. I think that colleges that had some experience with the capabilities of working through consortia would probably prefer the consortia rather than working with Washington, whereas colleges that had no experience working together might fear working together as colleges as much as they would with Washington.

Mr. VIVIAN. In other words, there would not be any clear indication as to which way such funds would be parceled out?

Dr. DIXON. I think it would probably have to be talked through and negotiated in each instance.

Mr. VIVIAN. Would this apply to staff projects, facilities, computers, and the other matters mentioned today almost equally?

Dr. DIXON. Do you mean would the agreements be greater on some matters than others?

Mr. VIVIAN. Yes.

Dr. DIXON. Probably. As has been said here, almost all of the colleges of the sort here represented are beginning to consider that a computer is as important as a library. When it becomes that common, you have kind of a common understanding that is different than the common understanding about the importance of having a faculty that can do basic research in physics.

Mr. VIVIAN. Supposing funds were made available either from NSF or from the Department of Commerce for projects directed principally toward improving the economic base of the Midwest or the Southeast by support through the smaller colleges. This then reaches to the smaller communities as well as the smaller colleges. Do you think the smaller colleges would have any reluctance to engage in a cooperative venture of this kind?

Dr. DIXON. There would be a wide variety of interest. I can think of many colleges that would not reject the proposal on intellectual grounds but would not care to divert their energy.

I can think of others, our own experience is the experience of being the center of the development of industry and technology in the Lower Miami Valley. You would clearly find some institutions that would be delighted. I would think these would be the institutions that saw themselves as having a closer and closer association with metropolitan areas in urban centers.

Mr. VIVIAN. If this should be done, it should be done with those who wish to come on a completely voluntary basis.

Dr. DIXON. I think that would get the widest participation.

Dr. ATWOOD. The metropolitan idea is rather critical here.

Mr. VIVIAN. I was making specific reference to the Southeast. Those of us in the Midwest, as the chairman well knows, have been pressing for better distribution of research funds to the Midwest, but I think the Southeast might stress it more.

It does not mean that you do not have places like Huntsville, but it does not permeate as well to your small cities and towns. You are probably more deficient in that than any other part of the Nation.

It is rather humorous to see you people labeled as the presidents of small colleges. Your accomplishments are great. I know this well from having dealt with you in the past, and as a student, getting a degree from a small college in Schenectady. I have three small colleges in my district, and another community college, there, being started, and I have a feeling that small colleges as such are simply evaporating away.

The teacher colleges grow very quickly in my State to factors-of-10 increases in size. What was known as Ypsilanti Normal College has now become Eastern State University, with 11,000 students at the present time.

I am curious to know whether or not the number of small colleges is stable, increasing or decreasing, and I exclude community colleges specifically. Do you know the answer to that question?

Dr. ATWOOD. It is slightly increasing. You find interests in various parts of the country, again of denominational groups, wondering if they can start a new college.

Mr. VIVIAN. Of principally a religious structure, is that correct?

Dr. ATWOOD. At the moment, in Atlanta, the Baptists don't have a college, and they have bought land on the northeast throughway, and they are trying to get started. I shudder to think of the problems they face in starting a new college today, but they think there is an educational need.

Mr. DADDARIO. Mr. Sullivan?

Dr. SULLIVAN. I am not sure this is really more than a footnote, but I think this kind of question almost needs to be dealt with partially in terms of history and what scale one is using and using the adjective "small" and so on, because it was the case not very many years ago that a small college tended to be of 600, 500, or 400. Now a small college tends to be one of 1,500, 1,100, 1,000, 900, and projecting ahead, I think it won't be—myself, I don't think it will be so very many days or years before it will be thought that a small college is an institution of 2,000 or so. The pressures economically on many of the existing institutions that have been quite small have been to expand to support an adequate range of faculty competence, to avoid a one-man department in some fields.

Many of the new institutions, at least I have the impression, are aiming toward this newer scale, rather than the older one, which many people have kept in mind as the desirable small college scale.

Finally, I think there is an enormous difference between the privately supported and the publicly supported colleges, as I am sure you are aware, in this respect. The pressures to expand on what have been small public institutions have been far greater than the pressures to expand on the independent colleges.

Mr. VIVIAN. I ask this question because in my own district we have 45,000 college students. It is 11 percent of the total population. We have one large university, the University of Michigan, with 40,000 students. It is scaled now to maintain any activity which a university has, but it is also so large that the students have rather difficult sociological problems, and we are trying to break the university down, going back to the scale I knew when I was an undergraduate going to college.

This has proved very difficult. We have one new church college, Concordia, a very excellent one. Two cities really need a college, and one has just gotten a community college. The problem there is it may have difficulty in taking on the scope of activities that a full 4-year college should be able to handle, and may be as much a hazard as a help. The other city does not happen to have a community college base, and the religious groups have not become interested.

I am curious to know, is there a vacuum here? In other words, is it very difficult to start a college at the 2,000 person level?

Dr. SULLIVAN. It is much harder to start a college than to kill it, I think. I suspect this should be kept in mind. I have the impression—Dr. Dixon might contribute to this, because I think some of the public regional universities in Ohio have attempted to cope with this by setting up local extension divisions, manned both by visitors and by resident faculty in communities such as I think you are describing. Isn't this the case, in places like Chillicothe, Ohio University?

Dr. DIXON. What Dr. Sullivan refers to is sort of a hybridization between the universities and community public funds, in which public funds extend the universities. It does not wholly answer the question you are speaking to because you are talking about, I think, the autonomous liberal arts college that has the maximum of academic freedom, the maximum of intellectual freedom in its makeup. I think the data are quite clear. Small liberal arts colleges are growing at the slowest pace of all the institutions in the educational hierarchy.

The principal problem in their replication is the capital funds for their construction. We note this in the recent publicity concerning the new Hampshire College. We have studied this in our college, and we are wholly convinced that we could replicate if we wanted to have undergraduate colleges of this sort if it were possible to capitalize the physical plant. There is sufficient affluence, and there are sufficient ways for those who are not affluence-supported by public moneys for education. We are reaching the point where the levels of tuition will support a responsible level of quality, but the characteristic device by which the private colleges have been created is by the private donation of capital, and this clearly is wholly insufficient if one were to have a new spirit of growth in the private colleges.

Mr. VIVIAN. In other words, the conditions for the formation of private colleges, except for religious organizations, are no longer very satisfactory?

Dr. DIXON. That is right, and particularly the condition of the capital financing, which has constantly become much more costly.

Mr. VIVIAN. Your comment about the growth of public institutions, which I think is quite correct, is that they will probably grow very rapidly. The chances are the only colleges left then in the small-college bracket in the next 10 years will be the private institutions supported by religious funds, which are small and growing very slowly, but because of the capital problem, with virtually no new input unless the churches take this on as a goal.

Dr. DIXON. This may be well an honest definition of the situation.

Mr. DADDARIO. Mr. Yeager?

Mr. YEAGER. Mr. Chairman, I would like to direct this question to Dr. Dixon, who spoke about the possibility of a new type of institutional grant perhaps being made available by the Foundation.

How would this differ from the developmental grant which NSF is now in the process of developing?

Dr. DIXON. It would use the experiences of the developmental grant as the basic experience to extend support to a larger group of institutions. It ought, I think, to be a grant, as the developmental grant, that doesn't make sharp distinctions between capital funds and operating funds. What would be needed, however, is to develop some rather elegant devices of accountability of institutions. The present devel-

opment grant is based on the narrow band of high quality reaching for higher quality and you can get the scientific community to help you significantly in making that distinction.

I would suggest that we couldn't afford to limit ourselves just to that band, that we have to go down below that and support potential for improvement—a rather more risky investment.

Mr. YEAGER. Well, the purpose would be roughly the same?

Dr. DIXON. The purpose I think would be roughly the same and the operation might at least be based upon the experience previously gained.

Mr. YEAGER. Several people have mentioned the difficulty of acquiring good science faculties. Could you give me what you think is the main reason for this? Is it the teacher load that Dr. Sawyer spoke of? Is it salary, the equipment, or the stimulation of other colleagues? What is the major reason, in your view, for this problem, if there is a problem?

Dr. ATWOOD. Perhaps it is a combination of all these things. Certainly each of those elements would come into individual circumstances. I would turn it around and ask what can we do to help. It seems to me the kind of institutional development funds that would do the most for upgrading this faculty might be relatively free—what we might call starter grants. It is for the young professor, who has finished his Ph. D., beginning to teach, but not yet able to come to AEC or DOD or any of the other agencies with a firm proposal. Some of us are using our own funds for this purpose, but NSF funds could help in this regard very much.

Mr. DADDARIO. Any further comment on that?

Dr. MCBRIDE. One further factor, even though you have six or eight factors there, seems to me to be the fact that sciences are expanding so rapidly that the very small department isn't adequate in its spread, isn't adequate in its range.

One of the most important reasons for the increase in the size of the smaller college is the increase in the faculty and its range of competence. It really isn't based on a student population problem at all. So we have I think in the sciences in many of our colleges been extending the number on the faculty, and as we do, we have a better chance of bringing people to the department, because the young person sees that it is a department in which he can work with colleagues who are important to him.

Dr. SULLIVAN. I have perhaps a couple of relevant comments. I referred earlier to our use of some university consultants in helping us to solve some of our complexities about going ahead with graduate work.

One of the most ominous things that they reported to us was the extraordinary number of Ph. D.'s at the time of finishing work in the graduate department that identify themselves as prospective members of university faculties rather than college faculties. This is true of a number of different disciplines.

I think the strengthening in the colleges of both the reality and with it the vision that the undergraduate student could have of a strong science program going on in the college would help to carry over toward some greater influence on careers.

The other comment is with the younger faculty members particularly in mind, we have used some of our institutional funds to provide very small summer grants as extra compensation to those young faculty members who wished to pursue a summer program and did not have any outside research grant. This has been extremely well received by our faculty.

We are also agreed in principle that something approaching a very early sabbatical program will be very much in order and we will follow it once we can find funds for it. This is after a couple of years of full-time teaching, the young man has a chance to have applied in the classroom some of what he has learned in the graduate school, this has changed somewhat his research ideas, and yet he is not in a position to compete for research grants, or simply to consolidate these different experiences he has had in the graduate school plus first-year college teaching. Some of the universities that are better financed are doing this and I think this gives them greater advantage in recruiting.

Mr. DADDARIO. I expected, of course, that this Panel would make a great contribution to the work of this committee. But the ideas which have been proposed, and the avenues of opportunity which have developed here today have been far beyond that which I could have expected. I regret, on the one hand, having kept you here so long, but we could not have let you go without taking full advantage of your presence. I want to thank you and to compliment you for your help to this committee.

Dr. MCBRIDE. Mr. Chairman, may we thank you for your very interesting problems and for the very generous time we have had in expressing our point of view.

Dr. ATWOOD. Also, for your willingness to let us represent the small colleges here.

Mr. DADDARIO. This committee will adjourn until August 19 at 10 a.m.

(Whereupon, at 1:12 p.m., the subcommittee was adjourned until Thursday, August 19, 1965, at 10 a.m.)

NATIONAL SCIENCE FOUNDATION

THURSDAY, AUGUST 19, 1965

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT,
Washington, D.C.

The subcommittee met at 10:20 a.m., in room 2325, Rayburn House Office Building, Washington, D.C., Hon. Emilio Q. Daddario (chairman of the subcommittee) presiding.

Mr. DADDARIO. The meeting will come to order.

We began these hearings on June 23, with an outstanding witness, Dr. Haworth, who is now, in accordance with our original plan, our closing witness.

We are extremely happy to have you before us again, Dr. Haworth. We also want to thank you for responding so quickly to the series of questions we submitted to you some weeks ago.

We are anxious to hear you.

STATEMENT OF DR. LELAND J. HAWORTH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. HAWORTH. Thank you, Mr. Chairman.

I understand the main purpose of this session is for you to be able to bring up questions that have occurred to you since I appeared before, either because you have thought of new subjects or because other witnesses have brought up things that you may wish to question me about. But I would ask your indulgence for a few minutes to make two or three particular points now, and then, if I may, I would like to have about 5 minutes at the end of the session to make a closing statement, if you will.

Mr. DADDARIO. You take as much time as you like, Dr. Haworth.

Dr. HAWORTH. Thank you.

First, I should like to respond to your remarks about the answers to the questions by taking this opportunity to say something more general, and that is that the work of preparing the answers to these questions, and of preparing the charts and so forth that lead to my original testimony was, of course, done by the staff. I want to say that I have never seen a staff respond more nobly than the NSF staff has done for these hearings.

I would especially like to pay tribute to Dr. Bowen Dees, who has led the effort and done it, I think, very, very well. I would also like to express my gratitude publicly to you, to the other members of the committee and to the other persons who have appeared before you.

51-204—65—vol. 1——49

Mr. DADDARIO. Well, I appreciate hearing that. I can very well understand how much staff work there has been in this.

I would also like to add that Dr. Dees has been helpful to the committee all through these hearings, and he was especially prominent during the seminar on scientific and technical manpower. We would like to add our note of thanks for his participation.

Dr. HAWORTH. Thank you, Mr. Chairman.

There are three factual matters that I would like to call to your attention today, because in one form or another, they have come up during the hearings.

First, there has been displayed, throughout the hearings, a great interest in the social sciences and the Foundation's support of the social sciences. It has been said correctly that we started late in the social sciences, and that we have tried to expand our efforts in them—expand them, in fact, more rapidly, relatively, than in other fields.

In this connection I would like to call your attention to the answer given to question A(6), particularly to the chart that goes with the answer to that question, in which there is an attempt to show the relative growth in the social sciences compared to the others. And, incidentally, in engineering, too. We simply normalized, as scientists would say, at the year 1960, which, incidentally, was the first year in which NSF gave multimillion-dollar support to the social sciences. The numbers at the left of the chart are indices of the relative support in succeeding years. And, as you can see, whereas the average support for all basic research project grants has gone up since 1960 by a factor of about 2.5, the support of the social sciences has gone up by about 6.6.

Now, NSF support of social sciences is still small. These are relative numbers, of course. I wouldn't make any claim that our support of the social sciences is large. But I do want to call your attention to the fact that we are definitely interested in the social sciences and want to press forward in their support.

The second matter is the support of fellowships in engineering. I sent you, Mr. Chairman, a copy of a letter from me to Dr. Augustus Kinzel. Dr. Kinzel has been under the impression that there was very little NSF support for graduate students in engineering. This was a mistaken impression, and I attempted to show this in my letter to him. I wrote Dr. Kinzel that his information was not complete. A briefer version of the letter has been handed to the subcommittee staff and I would like to call your attention to two or three points.

The first point is that in the totality of what we call "fellowships," the ratio of success of the engineers—that is, the number of engineers that are awarded fellowships as a fraction of the ones that apply, is just almost exactly equal to the average: Including all kinds of fellowships, 24.7 percent of the engineers that applied received fellowships; and the average for the Foundation was 24.3. In other words, there is no discrimination for or against the engineers, and there shouldn't be, because, of course, we do award these fellowships on merit, without relationship to field.

If it turned out that we could award 1,000 fellowships, and the best of the 1,000 were mostly chemists or biologists, or whatever, then they would get the fellowships. That could result from what the National Science Foundation Act tells us to do. But it doesn't

turn out that most of the fellowships go to one field. They are pretty well distributed.

This is even more impressive in terms of numbers when we look at the totality of the fellowships and the traineeships—they are all devoted to the same purpose—and the distribution there is also widespread.

The second, somewhat more complicated table shows that situation. Here I am talking only about the predoctoral fellows. (The figures I gave before included fellowships for teachers and postdoctoral fellowships and senior faculty fellowships and so forth.) The second table is for graduate students, and you can see on the right-hand column what the situation is with reference to the traineeships. You can see in the left-hand column the total situation.

Now, these figures can't be exactly precise, because the case of some of the traineeships, the institution is free, although we specify the field for many of the traineeships, there are some that are given to the institution to distribute as it wishes. However, as well as we can judge, of the awards this year, about 40 percent of the total predoctoral fellowships and traineeships will go to engineers. This compares with the fact that about 31 percent of all graduate students are engineers. In other words, at the moment, if anything, the engineers are getting more than a proportionate number of such awards.

Now, this will change downward somewhat over the next couple of years, because the fact that it is so high is affected by the fact that we started the traineeship program first in engineering. We have made traineeship awards for 2 years in engineering, for only 1 year in the physical sciences and mathematics, and not at all, yet, in the biological and social sciences. We will do the latter this coming spring.

So the 40 percent of all fellowships and traineeships that now goes to engineers will not be maintained at that level. My guess is it will drop to about 30 percent—that is, in proportion to the number of graduate students in engineering.

I should point out that to simply say 31 percent of the graduate students are engineers somewhat overstates the case. The figure includes both full-time and part-time graduate students, and a far larger fraction of the graduate student engineers are part time than are those in physics, chemistry, biology, and so on. This is because a great many engineers who have jobs in industry attend school part time, and this is much more prevalent among engineers than among others.

So, I merely wanted to emphasize to this subcommittee that there is certainly, in my opinion, no failure on the part of the National Science Foundation to recognize the need for student support among the engineers.

Mr. Daddario. Was there a difference here, because Dr. Kinzel was making a comparison with engineers as against all of the other sciences?

Dr. Haworth. That may well be part of it.

Mr. Daddario. My recollection of his testimony is that he was making a comparison in that sense. If that is so, is there any validity to that argument? Wouldn't it change the percentages?

Dr. Haworth. Well, Dr. Kinzel called me a day or two ago, after he got my letter. By the way, he is a very good friend of mine; there is no battle here.

I think he does have somewhat that feeling, that there is engineering and there is science, and he tends to compare engineering with all sciences.

I think that I would say that if one wants to draw a parallel, one could say there are the physical sciences on the one hand and engineering on the other; the biological sciences and the health professions; the social sciences—what one might call the "social engineers," although they are all included in the term "social scientists." Actually no term has been applied to the "social engineers," but there is an analog, of course. There are those who work in the more theoretical and basic aspects and then those who apply the social sciences.

But even if one draws such an analogy, I don't think one can say that there ought to be more engineers than physical scientists, or more physical scientists than engineers. It happens that if you group all these together in the graduate schools, a bit less than a third are engineers.

Mr. DADDARIO. If we had someone testify for the mathematical sciences, they could perhaps make the same kind of comparison?

Dr. HAWORTH. Perhaps so.

Now, then, the third matter that I wanted particularly to touch on today resulted from a remark of Dr. Grobman's, and again, I want to set the record straight, lest you get a false impression that we are going to get rich on royalties.

Dr. Grobman made the statement——

Mr. DADDARIO. We were interested, not that NSF is getting rich, but that if you were getting any royalties, at all.

Dr. HAWORTH. Well, this was just an off-hand remark of Dr. Grobman's, and I thought maybe I had better give the actual numbers.

Dr. Grobman made the remark that about $1 million had been received by BSCS and returned to the Treasury. Actually, the situation is that about one-half million dollars has been received in royalties and returned to the Treasury. It is a little less than that—about $480,000, something like that.

Undoubtedly, what Dr. Grobman had in mind about the other half million was that we allowed BSCS, as we have some of the other projects, to print extra copies of preliminary books that they used in their trial runs, and then sell those at cost.

As you know, the groups that are doing the curriculum studies prepare preliminary texts, then try them out at high schools, for example, that are interested in trying the new curriculum; schools volunteer, and are furnished free the texts that they are going to use. This is in return for their cooperation in doing the trial runs. And so there is a large printing of each preliminary book.

But there were, in this case and in some other cases, many requests from schools that weren't taking part in the trial run, that for one reason or another wanted copies of these texts. So we allowed BSCS to print, as I say, extra copies, and then simply sell them at cost. That is really not a return, of course, in the sense that the royalties are.

From all the projects, about $2 million has been returned to the Treasury, and there is another roughly $1 million, held in escrow by the various projects, that is returnable.

The BSCS project of which Dr. Grobman, of course, is speaking, is doing very well on royalties. For example, $151,000 was returned for the second quarter of this year. When you put all the projects together—and they are at different stages, so some haven't reached the stage of getting any royalties yet—there will be a substantial sum of money returned to the Treasury. But it is, of course, going to be a long way from repaying the cost of the curriculum studies. It never was expected that royalties would repay the cost.

Of course, in time, the royalties will drop off as the results of the curriculum work get out into the commercial channels.

Well, that concludes the special things I wanted to say, and I am at your disposal to answer any questions that you may have.

Mr. DADDARIO. Mr. Yeager.

Mr. YEAGER. Mr. Chairman, before we proceed, on the subject of the support of graduate education in engineering, I wonder if we might have this statement incorporated in the record.

Mr. DADDARIO. Without objection, it is so ordered.

(The statement referred to is as follows:)

NSF SUPPORT OF GRADUATE EDUCATION IN ENGINEERING

I should like now to furnish you some data concerning the Foundation's support of fellowships and traineeships in engineering, about which there was some discussion earlier in this hearing, specifically on July 15.

Since the beginning of the Foundation's fellowship program we have made it clear that engineering students were eligible to apply for predoctoral and postdoctoral fellowships in any area of training offered in engineering schools anywhere. All along we have had substantial numbers of engineering applicants and the number of awards made in engineering—in comparison with the number of applications—has been roughly the same as in other major classifications. In fiscal year 1965 our records show that the distribution of fellowship applicants and awards by field was as follows:

Field	Applicants	Awards	Awards as percent of applicants
Engineering	3,120	772	24.7
Mathematical sciences	3,595	1,017	28.3
Physical sciences	6,837	1,688	24.7
Life sciences	3,650	810	22.2
Social sciences	3,252	693	21.3
General science	85	13	15.3
Total	20,539	4,993	24.3

This table refers to all of our "fellowship" programs for American citizens, including the secondary school teacher fellowship program in which we make no awards in engineering. It does not include our graduate traineeship program, however.

If we now look at the support offered to graduate students through our graduate and cooperative graduate fellowship programs and through the NSF graduate traineeship program (from a second table which follows), it will be noted that NSF support to engineering students, due in considerable measure to the graduate traineeship program, is now at an exceptionally high level: we estimate that 40 percent of the predoctoral students the Foundation will support in academic year 1965–66 (from fiscal year 1965 funds) will be in engineering—at an estimated cost of $12.4 million of the $31 million obligated for the support of graduate students in all fields. Our percentage of support in engineering is higher by a substantial margin than the fraction (31 percent) of all science and engineering graduate students who are enrolled as students of engineering.

Distribution of predoctoral fellowships and traineeships by field, fiscal year 1965

	Total	Graduate fellowships			Cooperative graduate fellowships			Graduate traineeships
		Applicants	Awards [1]	Awards as percent of applicants	Applicants	Awards [1]	Awards as percent of applicants	Traineeships [2]
Engineering	[3] 2,399	1,235	273	22.1	1,276	296	23.2	1,830
Mathematical sciences	932	1,497	386	25.8	834	236	28.3	310
Physical sciences	1,727	2,629	643	24.4	2,013	440	21.9	644
Life sciences	453	1,476	343	23.2	724	110	15.2	....
Social sciences	431	1,571	289	18.4	741	142	19.2	....
Total	5,942	8,408	1,934	23.0	5,588	1,224	21.9	2,784

[1] Fellowships awarded to individuals by the National Science Foundation.
[2] Traineeships awarded to institutions and departments within institutions; selection of individuals is the sole responsibility of the institution.
The assignment of the 2,784 traineeships by field in fiscal year 1965 is based on the following assumptions: (a) that the 925 continuing traineeships will continue to be utilized in engineering departments (as they were in fiscal year 1964); and (b) that, of the 1,859 new traineeships, 905 will be in engineering, 310 in mathematics, and 644 in the physical sciences. It should be noted that the graduate traineeship program in fiscal year 1965 did not include life and social sciences.
[3] In addition to the estimated 2,399 in engineering in these 3 programs, 213 individuals were offered other fellowship support in engineering, bringing to a total an estimated 2,612 awards in engineering in fiscal year 1965.

I believe these data show that the Foundation is providing substantial support for engineering students and for more advanced engineers through its fellowship and traineeship programs. In fact, the data I have cited seem to me to show that NSF support of graduate students in engineering is at a level which should make engineers feel they are doing very well indeed.

In earlier testimony it has been suggested that it would be useful for the Foundation to assign a few fellowships to the general area of engineering design as a possible method of encouraging more students to work on theses of this nature instead of working on dissertations more appropriate for a doctor of science degree. The Foundation has to date maintained a position that the details of advising graduate students with respect to their field of specialization and the manner in which they should pursue their work is primarily a matter for decision by the university authorities where the students study.

For NSF to set a quota on the number of fellowship awards which it would make in a given field in terms of the type of dissertation that the students should undertake would be very close in our judgment to creating a mechanism by means of which undue influence could be correctly charged to NSF—that is to say, we could then be accused of interfering in the types of decisions which are more properly within the purview of the universities and colleges.

This is not to say that NSF is uninterested in the question which has been raised. We are currently supporting two major studies under the aegis of the American Society for Engineering Education on the basic question of the shape of things to come in engineering education: one of these studies is under the direction of Dean Joseph M. Pettit at Stanford University and concerns itself with graduate education in engineering: the other is under Dean George A. Hawkins at Purdue, and is concerned with undergraduate education. We hope that these two studies will be useful in helping to move those who are concerned with improving engineering education in the direction of creating a curriculum and all of the necessary relevant educational devices which will in fact make possible the type of special education for engineers which is most appropriate for the coming decades.

Mr. YEAGER. I have one question in regard to the above table, Dr. Haworth.

Dr. HAWORTH. Of that statement?

Mr. YEAGER. Yes, sir. You list there the graduate fellowships, cooperative graduate fellowships, and graduate traineeships. In

regard to the latter two, could you describe for us what the situation is there? Are these somewhat similar, and do you intend to keep this arrangement going as between the cooperative and the traineeships?

Dr. HAWORTH. Well, in the first place, you understand what the "regular" graduate fellowships are; they are awarded to people who apply directly to the NSF. They are evaluated; awardees are chosen. They then are free to go to whatever university they wish to attend.

At the other extreme, the graduate traineeships result from grants given directly to the universities on the basis of their proposals and competition. But the competition here is between universities, or more strictly, between the departments of universities. A university will propose that they be granted so many traineeships in the electrical engineering department, so many traineeships in the physics department, and so forth and so on. We then evaluate those through our panel system, and finally give awards to the university, spelling out that we have awarded so many in each of these subjects.

We also give some to the institution to distribute as they wish, and we allow some flexibility in the distribution, even of the ones that we have designated as to fields or departments.

But the heart of the traineeships program is that the universities are entirely responsible for selecting the awardees. They don't submit any names to us or anything of that sort. In other words, it is a grant to the university to be used for traineeships.

The "cooperative fellowships" are sort of in between. Here, individuals apply through their universities, through the university that they are either attending or plan to attend. A given man will apply to a given university, asking that the university, in turn, forward to us his application for a fellowship, for him to attend that university. In other words, he is selecting in advance the university that he will attend.

The universities, then, rate the applications that they have. They forward them to us, and then they are put through a rating system similar to that applied to the applicants for the regular graduate fellowships. We then select the number that we can award. So it is a national competition, but it is a national competition in which the applicant has already chosen his university.

Now, this was done in a deliberate step toward wider distribution of the fellowships than had occurred from the regular graduate fellowships, because what tended to happen, of course, was that once a fellow got an NSF fellowship, he wanted to go to one of about half a dozen universities. And there was a big concentration of NSF fellows in those universities.

On the other hand, the recipients of cooperative fellowships have spread out much more widely, and, of course, the recipients of traineeships more widely yet.

The first year of the traineeship program we awarded traineeships to, I think, 107 universities, which was within a very few of the total that give Ph. D.'s in some branch of engineering, which was the criterion for eligibility that first year.

This year we extended the traineeship program to the physical sciences and mathematics, and I believe 167 universities received awards. This year the criterion was that they must give a Ph. D.

in some one of the subjects that we covered—such as physics, or mathematics, or chemistry or engineering. This 167 includes virtually every university that gives Ph. D.'s, so we got a really wide distribution by virtue of these traineeships.

Now, in answer to the second part of your question, although there is not a formal decision, yet since the Science Board must consider it, we plan to omit the cooperative graduate fellowships and increase the number of regular graduate fellows and the number of graduate trainees. This is, in large measure, for administrative simplicity, both for us and for the universities; to have three kinds of what amount to graduate fellowships is getting a little complicated. So we plan to award no new co-op fellowships next year.

There are, however, 2-year awards. That is, a man is selected for 2 years but he is actually given his fellowship for only one, and the second year is dependent on having done successful work. If the university certifies that he has done successful work, he gets a second year automatically. Of course, those commitments or obligations will be carried ahead into the following year, but we will add no new cooperative graduate fellowships.

However, I should repeat that the Science Board has not yet formally endorsed this change.

Mr. YEAGER. This would not necessarily mean a reduction in the total support of this program though?

Dr. HAWORTH. No. As I say, we will distribute these among both the regular fellows and the traineeships.

Mr. YEAGER. Thank you.

Mr. DADDARIO. Mr. Davis, do you have a question?

Mr. DAVIS. Yes, thank you, Mr. Chairman.

Dr. Haworth, at the outset, I would just like to take this opportunity to express my appreciation for the work that you and your staff put into responding to the requests of this committee for information that we specified. These hearings certainly have been an enlightening experience for me, and I feel sure that this sentiment is shared by all the members of this subcommittee.

In that connection, it is well to remember that the committees of Congress who examine a particular question are usually looked to by the remaining membership of Congress to explain the situation to them, and I think that much benefit will accrue from these hearings.

There was one question that I wanted to ask, in the light of a discussion that we had during an executive session which occurred last Tuesday.

I made the remark that the organic act creating the National Science Foundation was so broad that you could go forward with such projects as Mohole, the Antarctic program, atmospheric research at NCAR, and many other things without the necessity of further authorizing legislation.

Now, question A–12 touches upon this point. In replying to that question, you review some of your experiences as a member of the Atomic Energy Commission, and you mention certain benefits which did accrue to the AEC and to Congress and the country, I might add, from the fact that the AEC had to have authorizing legislation.

I would be most interested to know your views as to whether or not you think that a similar authorization procedure would be beneficial to the National Science Foundation?

I might add, too, that in our discussion it was brought out that it may have been possible, within the purview of NSF's charter, to place many of NASA's activities under the National Science Foundation. A lunar probe is actually not too much different from a probe of the earth's crust as in Mohole. It is an effort to further our scientific knowledge.

Of course, this was not done. This committee was created primarily, I feel sure, to handle the authorizing legislation for our national space program. Since that time this committee has had a good bit of experience authorizing individual programs and going over NASA's budgetary items with a fine-tooth comb, so to speak.

I would be most interested to know your comments as respects more detailed authorizing legislation with respect to the programs of NSF.

Dr. HAWORTH. Well, first, Mr. Davis, let me thank you for your opening remarks, and then I will try to comment.

As I tried to say in my answer to the subcommittee's question, I really have had no experience with authorizing legislation, except in the sense that while I was a Commissioner at AEC, the Commission had authorizing legislation for its major facilities, for reactors, big accelerators, new laboratories, new production units, things of that sort. So I have had no experience whatsoever with authorizing legislation for a general program.

I was at the Commission only 2 years, but my observation was this: The real virtue of the interaction between the Commission and the Joint Committee on Atomic Energy—and I appeared many, many times before the Joint Committee on all sorts of things, from weapons to test bans, to high energy physics and so on—the important thing was that there was an interchange of information through the hearings that the Joint Committee held. They never had one, while I was there, that was analogous to the one that is just finishing here, that went through the whole spectrum of the Atomic Energy Commission's activities, but they had, each year, a number of hearings that went in depth into some phases of the program; it might be the civilian nuclear power program, it might be the program for nuclear power in space—reactors, or isotope energy generators for NASA's and the Air Force's space vehicles—or it might be on high energy physics. There was one such hearing just recently, in May, I think, that I took part in.

Those hearings were unquestionably of great value to the Commission, and from where I sat, it seemed to me they must have been of very great value to Congress. So this kind of hearing has a reciprocal value, I think, to both the legislative and executive branches.

Now, whether there is additional virtue in having such exchanges between Members of Congress and representatives of an executive agency focus around a particular authorization for a particular activity, I just don't know. I don't have any experience to bear on that.

This is especially so because the one aspect that the Commission did have authorization hearings on, namely big and expensive facilities—the Foundation doesn't have very much of. The Foundation's

support is more diffuse; except for NCAR and the two observatories we don't have any things that compare to the AEC's national laboratories or to the big production facilities at Hanford and Oak Ridge and Paducah and Savannah River and so on. Ours is a more widespread, small project type of activity. So I have no basis for really answering the question of whether hearings would be more or less valuable if centered around authorizing legislation. But I do say, with great conviction, that penetrating hearings in depth, on the various aspects of an agency's programs are a good thing.

Mr. DAVIS. Thank you. I believe that pretty well answers my question.

I think you would agree that it is a question that would be deserving of scrutiny?

Dr. HAWORTH. Yes, certainly.

Mr. DAVIS. Thank you, Mr. Chairman.

Mr. DADDARIO. Dr. Haworth, during the course of these hearings we have had some discussion about the National Science Board and its relationship to you, the Director. There were suggestions that the National Science Board have a full-time Chairman, and also that it have a staff of its own.

I have received a letter from Dr. Houston, who is a member of the Board, and in reference to the staff he says this:

> The staff of the Foundation is quite small when one considers the amount of money they must disburse in relatively small packages. On the other hand, the National Science Board has no provisional staff at all. The Director has always been most helpful in providing members of his staff to work for the Board, but the fact that their permanent assignments are on the Director's staff makes it difficult for points of view to be developed apart from those of the Director. Since the two Directors of the Foundation have been men for whom the Board has had the greatest respect, relations have been most amicable. But possible alternative policies may not always have come to the attention of the Board, but have been resolved on the staff, instead.

I would like your comment on that statement, and especially the idea that the alternative policies may not have had the opportunity to receive the attenion that perhaps they should have, if that is in fact the case.

Dr. HAWORTH. In the first place, let me say, I believe—I now speak quite frankly—I believe this would be a mistake, because I think we could have the possibility of two National Science Foundations if you try to separate the Board and its staff from the Director and his staff. And this would be a step in that direction.

However, let me then comment on the hypothetical point that Dr. Houston makes. I have not observed, in my brief tenure as Director any instances where the pro's and con's and the alternatives have not been fully presented to the Board by the Foundation staff.

I will not say that I and my staff have thought of every idea, every conceivable idea. Certainly we haven't. I would think if there were any virtue to having staff people who devoted their full attention to the Board, it would simply be that more people might have more ideas. But I don't see that that function requires that staff people available to the Board be divorced from the regular Foundation staff. It merely means that they should be assigned more time to think of the matters of interest to the Board.

In other words, my feeling would be a difference of degree, rather than of kind.

Mr. DADDARIO. You feel that the improvement in this relationship lies in the suggestion that you have made; not that the staff ought to be separate, but that it be beefed up somewhat and given a greater opportunity to work on the problems brought before the National Science Board?

Dr. HAWORTH. Yes. And we mustn't forget that the National Science Foundation is defined as the Board and the Director, and the Director is a member of the Board, and I just don't see—I just don't believe we should try to tear that apart. It has been a working entity that I think should remain.

Mr. DADDARIO. Then you feel that it becomes a question of further development of the idea that staff ought to be enlarged, but not necessarily separate and apart?

Dr. HAWORTH. Yes, that would be my feeling about that aspect of it.

Mr. DADDARIO. There also has been some discussion that the National Science Board should be just an advisory board. In this same letter there is another reference to that point, which I would like to read, and ask your comment about:

> I believe it is important that the National Science Board retain its present authority. One reason is that it gives the members of the Board a feeling of greater responsibility than would a purely advisory capacity. It permits the President to appoint members of greater stature, and it gives the scientific community a feeling that the Board, which to some extent represents them, can have some significant influence upon the policies, at least of the Foundation, itself.

Dr. HAWORTH. Well, I think this is a question of judgment, and it is very difficult to know which is the better way. I, of course, responded to your question B(1) on this and pointed out that at the present time in the statute there are a couple of difficulties. I think those difficulties could probably be resolved.

The first one, I certainly don't know how to resolve, but I think the real pro and con arguments go something like this:

The points that Dr. Houston makes are certainly good points, and I don't think there is any way to predict—or to assay, would be a better word—how much responsibility a board would feel, if it were advisory. I would point out that I don't know of any group that feels more responsibility than the President's Science Advisory Committee, which is advisory, and certainly the distinction of the members of that is very great, and their devotion is very great.

I personally feel that it doesn't make a great deal of difference, either way. There is this hypothetical chance that I mentioned in my answer to question B(1) that the Director would be caught in a difference of opinion between the Board on the one hand and the administration or the Congress on the other hand, and the statute, of course, gives the Board the power to make the policies of the National Science Foundation.

Now, actually, the Board, insofar as my observation has been concerned, fully recognizes the practical fact that the National Science Foundation, including the Board, has to work within the framework of the policy of the Government, but literally speaking, the act doesn't say that. So there is this hypothetical possibility.

Then there is, of course, the practical question that I also mentioned, that the Board meets only every couple of months. There are day-to-day decisions that have to be made that sometimes are difficult to make, and this is especially true in the realm of policy. Here it becomes a question of where do you draw the line and say "This is operation," and "That is policy"?

I say this because, as we all know, there is some policy in every action, and there is some action in every policy, at least a little in each case.

So it depends on how one defines policy.

The Board has delegated to the Director the power to carry out nearly all operational actions. There are some—I think it is something like 50—decisions each year on major grants and so on that still are beyond the power of the Director to decide, but as to those major ones, the time element is not likely to be too important.

The Board, however, does not have the power, even if it wanted to, to delegate policy even to its own executive committee, let alone the Director. So there are problems that arise in that connection.

Now, those are the difficulties with the present situation, and I suppose one would say are the arguments and reasons for making the Board advisory.

On the other hand, there are points such as those Dr. Houston has made. I think there is also the question of how the scientific and academic communities would feel about making the Board advisory, whether this would result in any less assurance on their part, is a psychological question that I can't answer.

Probably the scientific community feels more assurance than if the Board were only advisory. Certainly some individuals do. But how great that feeling is, I have no idea.

Finally, back on the other side, there is the other point that I made in my answer to your question; namely that although the act does not require that the Board adhere to governmental policy or go along with it in its public utterances the fact, of course, is that it does so. Hence some people have made the point that if the Board were advisory, it would be in a better position, on the one hand to question actions or policies it found itself in disagreement with, and, on the other hand, perhaps to give greater vocal support in the public sense to things it believed in, with respect to the Foundation and the entire governmental science structure, without being accused of being prejudiced. In other words, if they didn't have the responsibility and the authority, they wouldn't have quite so much feeling of reluctance about being proponents, so to speak. Now, again, I have no assessment of how important this is, but in reality, there have never been any of the kinds of serious problems that I said are theoretically possible. Both Dr. Waterman and I, as far as I know, have always been in accord with the Board.

There has been give and take on both sides, of course, when views were different, but everything has been amicable and there has always been a final consensus in which the Director and the Board would agree.

(The text of the letter from Dr. Houston follows:)

RICE UNIVERSITY,
Houston, Tex., August 16, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development,
House Committee on Science and Astronautics,
Washington, D.C.

(Attention Mr. Philip B. Yeager).

DEAR MR. DADDARIO: Dr. Eric Walker, Chairman of the National Science Board, has sent to the members of the Board copies of your letter of August 9 enclosing the 19 questions your committee submitted to him after his testimony on July 27. Since it appeared impracticable to convene the Board, or to get a significant concensus, he suggested that some of us might be willing to write you our personal views on some of the questions.

I must especially emphasize that the views expressed below are mine alone, but they are views based on almost 12 years as a member of this Board. The comments are numbered to correspond with your questions.

(1) The National Science Board is, I believe, unique in that a certain limited amount of authority is conferred on it by statute. It is possible that this authority has not been exercised as vigorously as might have been, but in any case such authority can extend only to the activities of the National Science Foundation itself. The Board can influence other agencies only through persuasion or through the Office of the President.

(2) The rather rigid connection between the system of divisional committees and the internal organization of the Foundation staff, although provided in the original act, possibly went somewhat beyond the conscious intent of the authors. The suggested reorganization provides a flexibility such that the divisional committee structure, as well as the staff organization, can be rapidly adjusted to the changing obligations of the Foundation.

(3) I doubt if the Foundation should have greater operational authority. Its peculiar function, and the area in which I believe it has been the most valuable, is in the support of small scale basic research in a wide variety of places and institutions.

I can remember that during the 1930's the Government operated scientific laboratories, at least in the physical sciences, were not highly regarded by the scientific community in the field of basic research. Among the reasons for this was that, in the field of basic research, originality is more important than experience. A research laboratory starts out with an enthusiastic staff and they all grow old together. In a university, the continuing influx of new students can produce a steady stream of new ideas. Most of them are bad, but they can be evaluated by the senior people. Government and industrial laboratories are now attempting to provide similar conditions, but it is not easy.

During the Second World War the idea of contract research in universities was developed to remedy the deficiencies felt in the Government laboratories. At the end of the war, efforts were made to perpetuate the scheme through the Office of Naval Research, the Research and Development Board, and then through the National Science Foundation. The Foundation has been most effective in this aspect of its work.

It must be emphasized again, that the above comments refer only to basic research. Work in applied research and engineering may very well be done in institutions devoted to such research and engineering only.

(7) I believe it is important that the National Science Board retain its present authority. One reason is that it gives the members of the Board a feeling of greater responsibility than would a purely advisory capacity. It permits the President to appoint members of greater stature and it gives the scientific community a feeling that the Board, which to some extent represents them, can have some significant influence upon the policies, at least of the Foundation itself.

(9) The staff of the Foundation is quite small when one considers the amount of money they must disburse, in relatively small packages.

On the other hand, the National Science Board has no professional staff at all. The Director has always been most helpful in providing members of his staff to do work for the Board, but the fact that their permanent assignments are on the

Director's staff makes it difficult for points of view to be developed apart from those of the Director. Since the two directors of the Foundation have been men for whom the Board has had the greatest respect, relations have been most amicable, but possible alternative policies may not always have come to the attention of the Board but have been resolved in the staff instead.

In conclusion may I express the gratitude which I feel as a member of the Board for the effective way in which your committee is studying our operations.

Very truly yours,

W. V. HOUSTON,
Member of the National Science Board.

Mr. DADDARIO. Mr. Roush.

Mr. ROUSH. Dr. Haworth, I am not real sure that this is a fair question to ask, but the question is prompted by an experience I had a few years ago. I serve on the board of trustees of a small college in northern Indiana, and this college was seeking its north central regional accreditation. In the process of seeking this, we had to go through a period of self-criticism and writing a report which actually was the result of our own self-study of weaknesses, and our potential, and our strengths.

As a result of this we learned a great deal about ourselves and the school was strengthened because of it.

I would imagine that because of your coming in relatively new, into this position as Director, that the Foundation has done the same thing. I would also imagine that because of these hearings that you have examined yourself very carefully. I think it is apparent from this report which we have before us, which is a response to the questions the committee had. I wonder, as a result of that, if you have discovered, shall we say "weaknesses" or "inadequacies" or any policies which should be changed, administrative processes which should be changed, which have not come to the attention of this committee?

Dr. HAWORTH. Well, first, let me say that you are quite right on your first two statements; one, that we are constantly analyzing ourselves, and we have, as I told you in my first appearances, not only a constant look at ourselves in the sense that a staff always does, but we have two mechanisms that have been set up since I came to the Foundation to do this. One of them is what we call the Planning Council, which consists of myself as chairman, the deputy director, the associate directors, and equivalent, we use the term "associate director" only in the substantive parts of the program, but the Comptroller, for example, is one member of the Planning Council, the General Counsel is a member and, the administrative manager, who is responsible for all the administrative activities of the Foundation, is a member. The Planning Council does a great deal of the sort of analysis that you are talking about.

In addition to the Planning Council, we have a planning staff under Dr. Dees, who is the Foundation's Associate Director for Planning. Dr. Dees' organization has two branches in addition to the Office of Economic and Manpower Studies. One is the Office of Program Development and Analysis, which is responsible for the internal planning of the Foundation; and the other is the Office of Science Resources Planning, which is responsible for planning in terms of NSF's responsibilities with respect to the totality of the national program in science.

In making this effort to strengthen NSF's organization for planning I was not motivated by a feeling that anything was particularly wrong with earlier Foundation planning efforts. It is more a ques-

tion of, "Here we are, where do we go from now on to improve the situation?"

In some instances we have tried to simplify things, because some of the administrative methods, for example, that were appropriate to a small organization become unwieldy when they are applied to a big organization. On the other hand, planning of the science development program which was under discussion but not crystalized when I came to the Foundation, has resulted from this kind of organized thinking.

We are giving a great deal of thought now to what ought to be our future long-range role in science education, particularly in view of the great upsurge of interest in the country as a whole, led by the President and the Congress, and, of course, the Office of Education.

Now, the second statement you made, Mr. Chairman, has made it so I need speak only 4 minutes at the end, instead of 5. I wanted to say, as you have pointed out, that this hearing has contributed very greatly to our turning our eyes inward on ourselves and trying to think hard about where we are going and what we are doing.

It shouldn't be true, but it is true that most organizations are likely to take a thorough look at themselves and come up with new ideas only when something happens to prod them into doing it. And it is also very true—and this is an observation that I made originally during the war—that it helps a great deal to have to write things down as we wrote down the answers to your subcommittee's questions. During World War II, I was at the radiation laboratory at MIT which developed microwave radar. The laboratory started from nothing and had 4,000 people by the end of the war. It happened that after the Japanese surrendered, I remained on for about 6 months to help write the report of microwave radar during World War II. And I remember remarking to Dr. DuBridge that I had more good technical ideas while I was writing my part of this report than I had during the entire war, and that I thought there ought to be, in the next war, an understanding that every 6 months we would stop for a month and write, because it forces one to assembly his thinking.

And this hearing in addition to the virtues of our exchange of ideas orally, has forced us to do a great deal of thinking, because some of the things that were pretty nebulous in our mind, had to be put down fairly precisely in answer to your questions.

Mr. Roush. I think we would be glad to hear any new ideas that developed as a result of writing this.

Dr. Haworth. I don't think we have reached the point of forming any new, brilliant ideas. But we have certainly realized that there were many things that we had to focus on and try to do more about.

The discussions of the social sciences, of how science is to play a stronger role in what I will call the problems of society, and the question of geographic distribution of science resources and support. The geographic distribution problem wasn't new to us, but we have some different impressions about it, perhaps, than we had. But I don't think there have been any brilliant new ideas.

Mr. Roush. Well, perhaps some have been conceived which are still in the embryo stage, and some day will make their entry, then——

Dr. Haworth. I am sure that is so.

Mr. Roush (continuing). Into the world of open thinking.

Dr. HAWORTH. Of course, ideas of this kind can't be identified quite as concretely as technical ideas about radar.

Mr. ROUSH. That is all, Mr. Chairman.

Mr. DADDARIO. Mr. Mosher.

Mr. MOSHER. Thank you, Mr. Chairman.

Mr. Davis referred to the breadth of your charter. I have been curious to know whether you sometimes feel vulnerable because of its breadth. Do you sometimes wish that it might be more precisely stated in limiting terms? Would there be any cause for us to consider legislation which would limit it?

Dr. HAWORTH. No.

Mr. MOSHER. For example, are you glad that you have Project Mohole? Would you welcome legislation which would take projects of that sort and put them in some other agency?

Dr. HAWORTH. I would have to confess, facetiously, that there have been times when I wished that Mohole had been started, so that I could crawl into it.

Mr. MOSHER. Seriously, does that belong in your purview; this is what I am asking.

Dr. HAWORTH. I think so.

My answer to your general question is that I think the broad charter, that the Foundation has, has been a very fine thing. I think Congress was very wise to write it that way, and I would hate to see it be restricted in any sense.

You see, these things like Mohole are permissive. The law directs us to do research, that is to support research—we don't do research—to support research and support science education and so on, but the directives in it are in very general terms, so that if it seemed inappropriate for us to do a particular thing, such as Mohole, there is nothing that forces us to. And, of course, the flexibility allows for a great deal of give and take between us and the other agencies. Here I would like to rephrase something that we have tendered to say and that other people have tendered to say about that.

There has been a good deal said to the effect that the National Science Foundation is sort of a gap filler or a balance wheel or something of that sort. I would rather say it the other way around—and this is one kind of thinking that has grown out of these discussions, incidentally, that Mr. Roush referred to—I would rather think of it the other way around; that the Science Foundation has a responsibility to see that the scientific health of the country is good. And I think that one should say, one can say, that this is a mission. It has two facets, one the support of research and one the support of education, but the scientific health of the country is really the Foundation's mission.

Now I would rather describe NSF's relationship with the basic research and support of education of other agencies by saying that we should take every advantage of what they can do, rather than by saying, "We are going to be here as a sort of service of supply and they are going to be the fighting troops; we are going to be the reserves and just fill in the gaps where they appear in the line." I think we should be in the forefront, but we should take account of all the capabilities and support that the other agencies can give and are giving, rather than say we are just the fillers-in.

Mr. MOSHER. Now you say that you did not have to take on Mohole, that it was not forced upon you. But I can see where in the national interest an increasing number of major engineering projects have to be done. When I suggest that you might feel vulnerable, increasingly Congress might be pushing onto you a lot of these big engineering problems and projects. Would you feel vulnerable in that respect?

Dr. HAWORTH. Well, I would like to make a distinction here, and that is that while Mohole, in its present phase, is a big engineering project, that phase has as its objective the providing of some facilities to do some basic research. It is analogous to building a big accelerator or big radiotelescope or other things of that sort.

I do not think it would be appropriate for the National Science Foundation to go into an engineering development such as the Mohole platform and drilling equipment, except as a means to the end of doing basic research. But the act, you see, doesn't provide for our doing that sort of engineering development. The avoidance of this sort of thing is, to my mind, one of the reasons why we have to be cautious about getting into applied research. For just the reason you mentioned.

Mr. MOSHER. Thank you.

Mr. DADDARIO. Dr. Haworth, to follow up Mr. Mosher's question—and I think he has an extremely good point—you get involved in an operation such as Mohole, and, as Mr. Davis has already suggested, perhaps if there had been authorization control this might have been looked at more closely.

We have now reached the point where we are talking about the expenditure of $110 million for Project Mohole. This is far above what was originally estimated. One must also look to the value of Mohole as against other programs that you might support. Isn't it then a stringent requirement on all of us to look into this aspect of NSF's activities? Should it, in fact, get involved in programs of such vast depth? Doesn't it reach the point where it will have a weakening influence on your other activities?

I think this follows closely with Mr. Mosher's concern.

Dr. HAWORTH. Yes, sir. I would like to make, if I may, Mr. Chairman, a couple of specific remarks about Mohole, and then discuss the question more generally.

You mentioned $110 million. Now I think of this in quite a different way.

Mr. DADDARIO. I am just using your figures.

Dr. HAWORTH. I know, but this is because I am asked for figures. I like to think of it in the following way: As I said in partial answer to Mr. Mosher, the present phase of the project is to provide some facilities for doing deep drilling under the ocean. Now, part of the objective of that deep drilling is to penetrate into the mantle of the earth, but that is only part. And to say that the Mohole project is going to cost $110 million or whatever it might be, up to the time that one does penetrate the mantle once, I think is not really the right way to look at it.

One should say, how much does it cost to get these facilities into being? Our present estimate of that, incidentally, is somewhere between $75 and $80 million. That is, to have done all the research and development that is necessary to develop this kind of facility, to con-

51-204—65—vol. 1——50

struct the platform and the drilling equipment, to make the site surveys, to know where we are going to go first to drill, and so forth. Then we will go drill. We won't even try initially to drill as deeply as the mantle. We will drill half a dozen or eight or whatever, or even more, maybe, holes to lesser depths. Then at some point we will go to one place; namely, as we see it now, off Hawaii and sit there for 2, 2½ years, something like that, trying to drill a very deep hole to the Moho. But when that is done, that is only the beginning.

In other words, in one sense to say that the Mohole project will cost $110 million is saying too much; and, in another sense, it is saying too little, because I am sure this equipment will be used for years and years and years to do other drilling. There may possibly be no need to drill more than one hole to the mantle, but there certainly will be need to drill lesser holes around various places in the ocean.

It is analogous to the big accelerator that the Lawrence Radiation Laboratory built at Berkeley starting in the late 1940's. One of the things that we had in mind—I say "we" because it was a concerted program of the AEC to build two big accelerators, one of which was built at Brookhaven, where I was, and one at Berkeley. Brookhaven was a new laboratory and didn't have much of a staff at that time. It was decided that we should build the smaller one—still very big, compared to anything that had been built—and that the Radiation Laboratory, should build one of six or eight or whatever billion electron volts.

Now, in order to get, to be able to create negative protons, we knew that one must have an energy of at least 5.6 Bev, billion electronic volts. So it was decided between the two laboratories and the AEC and the AEC's General Advisory Committee that the Berkeley machine would be at 6 billion volts, so it would be safely over the threshold required to make negative protons. But it never was called the negative proton project. It was called the Bevatron meaning Bev-tron. And it was thought of as a general research tool which had been built to have the capacity, the capability of doing this particular thing. That decided how big it was, so to speak. But nobody spoke of "How much is it going to cost to get the negative proton?" We spoke of "How much is it going to cost to build the bevatron, and then use it for research?" One of the early major programs that was carried out was indeed to get the negative protons, which was done in 1954, something like that. But I like to think of those two things—the Mohole facilities and the Bevatron facilities, as being analogous as to cost.

Now turning to your general question, this is a very legitimate question to ask about Project Mohole, and about the national astronomy observatories, and NCAR; in other words, these large-scale things that, once undertaken, are commitments to follow on and are "big science," if you will. I believe that in the areas of basic research the National Science Foundation definitely has a role, should have a role in doing this sort of thing. It doesn't have such a role, for example, in the biggest accelerators. This is in the AEC, the natural consequence of the fact that the biggest accelerators were an outgrowth of nuclear physics, ordinary nuclear physics, and also the fact that the logical first home for these very big accelerators was in the national laboratories of the AEC. Had history been otherwise, it might well have been logical for the Science Foundation to do that

and maybe sometime they will, I don't know. That is, take some part in it.

We have, of course, as you know, financed an accelerator of about 10 billion volts at Cornell at a cost of about $12 million. But that was because it was a university accelerator as distinguished from the national laboratory type of institutions that build the very biggest accelerators.

There is no question that a great many people think of this as being in competition with what they call little science, in competition with the small project grants that are scattered around among innumerable universities and colleges, but I think these big projects must be done, and I think the National Science Foundation should do its share. Perhaps its share is larger than most.

Mr. DADDARIO. Mr. Davis, do you have any further questions?

Mr. DAVIS. Mr. Chairman, I have just one observation. If the National Science Foundation had not had the authority to go forward with Project Mohole, and if some Member of Congress had introduced a bill which would have authorized NSF to carry out Project Mohole, when that bill was brought before a committee and hearings were held, and then it went before the Rules Committee of the House, and the whole project was discussed and debated on the floor of the House, I can't help but believe that the word "boondoggle" would be the most frequently heard word in the debate. This project involves such an esoteric pursuit that it is difficult for a person to judge its merits. The average Member of Congress is a layman in the scientific sense. I think Mr. Vivian is probably one of the few Members of Congress that does have a real scientific background. The thing I am leading up to is that perhaps it is better that a project such as Mohole is handled in such a way that it doesn't require a complete airing out in public.

If the scientific community agrees that it ought to be done, maybe it is better that it can be done without the necessity of a full public airing, because the general public is so far behind the scientists in deciding where substantial effort ought to be put forth in these strictly scientific endeavors. For that reason, perhaps, you are better off because of the broad charter for NSF since the only committee in the House of Representatives that really has to examine the propriety of your proposed expenditure is the Appropriations Committee.

Would you care to comment on that?

Dr. HAWORTH. I think I would make just this one observation: That is, I think that deciding on what, among the great variety of scientific things could be done, that that is more difficult for Congress than to decide among the variety of, say, social things that could be done.

Of course, also, in a sense, except for the question of the funds, which is involved in both cases, it has less direct impact on the public. Whether we do Project Mohole or some other science project has for less impact on the public than whether you pass one piece of social legislation or another piece of social legislation.

Mr. DAVIS. That is true. We have a hard enough time with that, I might say.

Mr. DADDARIO. Don't you think, following that one up a bit, that if you can properly explain a project and excite the public by it, that

you have also contributed something to the whole field of educational effort which is, in a sense, behind everything we are trying to do?

Dr. HAWORTH. Yes, that is right. As I said earlier in response to some of the questions about authorization legislation, I think, to have Project Mohole and these other things discussed in hearings is a good thing. I am not competent to judge whether it should be an authorization hearing or a hearing in a more general sense.

Mr. DADDARIO. Mr. Conable.

Mr. CONABLE. Doctor, at this stage in the proceedings, I wonder if you have any requests to make of the committee. For instance, do you feel that there has been sufficient dissemination of information about these hearings? What will you expect of us in this line, in order to perhaps improve your general relationship with the scientific and academic community? I would like to leave it just in a general frame. Now that the committee is beginning to deliberate and trying to digest the great mass of information that has come in, are there any areas of concern that you have? I think it would be helpful to us to know what they are.

Dr. HAWORTH. Well, you asked two or three specific questions. Let me answer first the question of whether there has been enough public information about the hearings.

I would divide my answer into two parts. Certainly the scientific and academic public are very much aware of these hearings. There has been a great deal published in periodicals such as Science magazine, for example. As I said, scientists are very much aware of the hearings, and their reactions, initially, have been—as far as I know, and I have seen nothing to the contrary—have been very favorable to the way the hearings have been conducted. The fact that you have had such a very representative set of witnesses, and the searching but the sympathetic way in which you have asked your questions and so on, have been very helpful.

Now, with respect to the general public, I really don't know, but I am not nearly as aware of a general public interest in the hearings. There were, of course, newspaper stories when the hearings started. There have been some, from time to time, about some aspect of other, but certainly, as would be expected, there has been nothing like the interest, among the general public, that there has been among those more immediately affected.

I think that one of the very great virtues of the hearings, which will happen automatically to a considerable extent, is a thing that Mr. Davis referred to in his original questions, namely that clearly the rest of the Members of Congress look to this committee for knowledge and information about the National Science Foundation. And I think the greater the variety of ways in which they become informed and learn more about us and what we are trying to do and what our strengths are and what our weaknesses are—and we certainly have weaknesses—the better it is. You asked me what you can do. I think one of the things that would be most helpful to us is for you to intensify that information process as much as you can, because the more knowledge everybody has about any subject, the better. I believe in people being informed. And I think that the more you can do to make the rest of Congress aware of these things, including the bad side, the better.

It is also true, though it is a more ephemeral thing, with respect to the public, that the more Congress as a whole can do to make the general public aware, not just of the National Science Foundation but of the total picture of science as it affects the country, the better; and—particularly because of your responsibilities and ours—the role that the Federal Government plays in all this, because there is certainly a great lack of understanding among the public about what science really is. Even such magazines as Time and Newsweek and Life and various other magazines, will have on a page labeled "science" something that isn't science, at all. It may be an application of science or it may be a gadget.

I think that you, who represent and visit among all the people of the country, can help a great deal in creating a better understanding of what are the aims, the objectives, the utility and the needs of science.

Mr. CONABLE. Do you feel there are any gaps in the inquiry that should be filled before we retire to deliberate?

Dr. HAWORTH. I am not aware of any.

As a matter of fact, before we answered all these questions, I thought we probably should end up by writing a document that pulls some of these things together. But the hearings have been so complete and the questions so searching that I feel that virtually everything has been said that needs to be said.

Mr. CONABLE. In other words, you are willing to stand on this record?

Dr. HAWORTH. I am willing to stand on this record, yes.

Mr. CONABLE. Thank you.

Dr. HAWORTH. I know that there was some question of whether we could get the questions answered in time, but I really believe, Mr. Chairman that the record is pretty complete, or so it seems from where I sit.

Mr. DADDARIO. I am glad to hear that.

Mr. Vivian.

Mr. VIVIAN. As I am sure you are aware, there have been suggestions that there should be roughly a 15-percent per year increase in the support of the sciences generally, but the National Science Foundation in particular. The argument was based, to a very considerable extent, on the growth in population and the growth of persons trained in science, with the percentage of those trained in science I believe holding fairly constant. Also, in light of the fact that there is about 50 percent of our total population below 25 years old, and the total number of students in college has risen by 50 or 60 percent in only a few years, these are causes for a 15-percent rise.

Looking forward to the possibility that such a 15-percent increase will be approved by the Appropriations Committee, which is only a possibility, I have heard very little information on the subject of exactly where NSF would spend these additional funds.

I would like to know in particular what technical fields you anticipate will receive this 15-percent expansion. Finally, what new international role you would expect to have with this percentage increase, an increase which would double the size of NSF's budget in another 5 years.

Dr. HAWORTH. Well, let me start by clarifying a little the question of the 15 percent.

Actually, this 15 percent was an attempt—in the last budget year and this one, because we don't yet have anything better for this one—to make some kind of a prediction of what the requirements will be.

Now, this applied only to what I call academic science. These demographic arguments which were the basis, of course, were applied to the universities and colleges on the basis of growth of student population. Also, the 15 percent is supposed to be the total, the Federal rise, not necessarily the NSF rise. But NSF, in this case, was a sort of stopgap, or the balance wheel in the 1966 appropriation request.

Mr. VIVIAN. I would like to say if the 15-percent increase were applied across the board to the $15 billion total which the Federal Government has been spending in research and development, the increase would be far greater. If it was only in the research area, it would still be quite large.

Dr. HAWORTH. I was being more restrictive than the research area. I was saying only the research area because the universities don't do development, really. Only the research area and only the research area in the academic institutions. So it is—what is it—about $1.5 billion that goes to the universities, to which the 15 percent would be applied.

Mr. VIVIAN. Yes.

Dr. HAWORTH. And, as I say, this was thought of as the total Federal support of the universities for research, that ought to go up to about this rate, and then it was said that the NSF's support of the universities ought to go up—would, perforce, go up more than 15 percent, because some of the mission-oriented agencies aren't going up that fast.

As I said, this judgment was based essentially on a demographic argument. You are quite right in distinguishing between little science and big science in this respect, because I don't know how one can predict big science. It has its ups and downs. You build a big accelerator, committing a great deal of money in one year, and there may not be nearly as much in the next year or there may be in another year two big things, and so on. And I don't know how to make any statistical prediction about that sort of thing.

Now, with respect to whether the 15 percent is right, or not——

Mr. VIVIAN. Let me suggest that we do not argue whether it is right for the moment. I would like to know, if you get the funds, what do you do with them?

Dr. HAWORTH. Let me say I think it is in the right league, but we must find better ways to determine it.

I don't have any basis for saying that the distribution of support among the various fields and disciplines of academic science, is likely to be in the next few years very different from what it is now. For one thing, the distribution is determined by the interests of the existing faculties at the universities. And these will not change in proportion very rapidly. You aren't going to make biologists out of very many physicists, although occasionally one becomes a biophysicist, and so on.

There are some fields that are coming forward more rapidly than others, ones that perhaps got started later, and some of the interdisciplinary fields. Certainly biochemistry has come along very rapidly in the past few years, compared to other kinds of biology or other kinds of chemistry. But my feeling is that in this realm—and again I am not getting into the research supported for special ends, either in Government laboratories or in industry or development or things of that sort—that it is largely a self-governing mechanism; that as fields become more productive, scientifically, then more interest is created, and more people go into them.

But I don't see any sharp trends.

Mr. VIVIAN. You don't anticipate applying what I will call "Washington enthusiasm" to any given subjects?

Dr. HAWORTH. Well, there is a certain amount of that but in the activities that we have it is not a very dominant factor. As I said earlier, we recognize from time to time that there are areas that aren't being supported well enough. A good example that I don't think I mentioned before was that way back, long before my time, it looked as though the old classical field of systematic biology was going to lose out because of the popularity of other newer fields such as molecular biology and so forth, and the Foundation deliberately started a program of support for systematic biology. It was a modest program but it kept the field from withering.

Another example, where the Foundation decided it ought to put additional emphasis was organic chemistry. Hence proposals in that field were especially encouraged. We have given some special emphasis to the atmospheric sciences, and certainly the Federal Government has done so in oceanography, partly because of the interests of the agencies, partly because of that of Mr. Kennedy and, partly because of Congress interest. And I think these field sciences will probably grow relatively more in expenditures than the more fundamental sciences.

Mr. VIVIAN. Can I ask then about the big science——

Dr. HAWORTH. And the stimulation of interest in Washington undoubtedly is helping that process.

Mr. VIVIAN. In terms of little science, then, you would anticipate that it would be determined largely by the distribution of faculty interests existing at the time?

Dr. HAWORTH. And of course, their successors.

Mr. VIVIAN. Five years from now, what do you anticipate will be the projects that NSF will be supporting in big science?

Dr. HAWORTH. Well, I could answer this better after we get all the reports of the studies that the National Academy is making, but I can give a few examples. I really shouldn't qualify or shouldn't identify all this as big science, but, for example, there is a very definite need for more facilities in the field of astronomy, ground-based astronomy—for more of the larger optical telescopes, for bigger radio telescopes, particularly various kinds of large arrays which seem to be the best way to get very high resolution. There is a need to get some high resolution, both optical and radio telescopes, in the Southern Hemisphere, for example. There is very little down there.

One field that I wouldn't classify as big science, because of its usefulness all across the board, but it is big money, is the computer field. The needs of the universities, for example, for computers——

Mr. VIVIAN. You don't see yourself developing computers, but rather supplying them; is that right?

Dr. HAWORTH. Yes. I think there should be a very few computer development centers in the universities, but that is not really the thing to which I am speaking.

I think that there is going to be a terrific growth in the need for computers for the support of the sort of science that they are already supporting, for greater use in the social sciences, for use in education, and so on.

I think that the universities are also a place to develop software, as compared to the computers themselves. This means the ancillary things that go with the computer.

Mr. CONABLE. Will the gentleman yield a minute on that point?

Mr. VIVIAN. Yes.

Mr. CONABLE. I was under the impression that the computer industry was very competitive and that it was constantly seeking new ways of processing data. Yet, it appears that this is something that requires Federal support.

Dr. HAWORTH. Well, I am speaking about a particular facet of computers.

The ways in which, for particular fields of science or for the particular needs of universities, you make use of the central core computer.

I am not speaking of computer development—although, as I said, I think there should be a very few centers of computer technology, proper, just as there should be in any field, because after all, industry has to draw its people from the universities. If for no other reason, there should be a very few centers where the basic technology of the computers themselves is worked on.

But I think that, more importantly there is need for greatly increased support of some of the other aspects. There needs to be, for example, a great deal of thought and some trials in connection with this question: if there is need for processing a great deal of data in a given university or even in a larger area, is it better to have a very large computer and then have satellite stations that feed into that computer, or is it better to have several smaller computers scattered around?

Now, that is not a big science in the same sense that Mohole is big science, but as I have said, it is big money.

Mr. VIVIAN. Big money in the universities?

Dr. HAWORTH. But it is in the service of both little and big science.

Mr. VIVIAN. Are there any specific projects in big science in which you expect to be involved?

Dr. HAWORTH. Well, there are some. Certainly, in the example I gave of astronomy. If we are going really to keep pushing in astronomy, there must be some very major facilities. Now, I am not saying that they will be built, or that if they are we will build them, but this is a natural field for the National Science Foundation.

Another example, of course, is space-based astronomy, where NASA of course, has the responsibility for the platforms and things of that

sort, but where I think other agencies should ride piggyback with their equipment to take advantage of the platforms.

Departing now from the Science Foundation, there is certainly a need for much larger particle accelerators if we are going to really solve the problems of elementary particle physics.

Mr. VIVIAN. This would be under AEC, in your view?

Dr. HAWORTH. Yes.

Mr. VIVIAN. I am trying to stay strictly within NSF. What do you see there.

Dr. HAWORTH. I don't think I can put my finger on any.

Mr. VIVIAN. May I switch, then, to the international role, Doctor? Do you foresee activity there?

Dr. HAWORTH. This is something that we have been discussing in the Foundation a great deal, but we haven't come to any definite conclusions.

There are really four areas of international science. There is the area of cooperation like the IGY, or the IQSY, or the Indian Ocean Expedition, or the Antarctic program, where there is a concerted activity in which planning is done internationally, but where each country carries out its own program. This cooperation, of course, is in the interest of science, although we put great stress on the fact that it also helps international relations.

A second area is where for one reason or another a Federal agency might support science in another country because—let's say in advanced countries, like those in Western Europe—because for some reason something we would like to see done can be done better there, than here; either they have a group of people that are unusually well qualified, or there is a geographic aspect to the scientific activity, or something of that sort. I don't foresee any great increase in that kind of thing.

A third area is at the other extreme. It is the support of science and science education in the developing countries, where obviously the principal objective is not to get something that is immediately useful in the scientific sense, but where the objective is to help the country develop; in other words, where it is really a foreign policy objective. The Science Foundation clearly does not, with its present charter, have authority to support that sort of thing, because our support is supposed to be for the benefit of American science. We do, however——

Mr. VIVIAN. You do subcontract to AID, however.

Dr. HAWORTH. We do, yes; that is what I was coming to. We do, however, have a certain amount of activity carried out on behalf of AID with AID funds; our activities in Central and South America are of that kind. I would like to see more of that. I think that the Science Foundation has certain capabilities, because of its relationship with the scientific community and so forth, that can be put to very good use.

Then, finally, the fourth area is what is customarily referred to as the "gray area," which lies in between, where the science is good but not necessarily any better than, or quite as good as, the science you could support in this country, but where foreign policy objectives are involved. This is the activity that we don't quite know whether we

ought to undertake or not. Should we, other things being equal, support some science in some place where our foreign policy objectives would be helped, even though we could get it done just as well at home. In other words, should we apply to this the same criteria that we now apply with respect to geographic distribution within the United States, where if we can get it done equally well in more than one place, we take geographic distribution into account. I just don't know whether we should get heavily into that sort of thing or not. And I think this doesn't apply just to the Science Foundation; I think this is a question that would be fruitful for Congress to think about—how the objectives of science and the objectives of foreign policy can be combined effectively and appropriately.

Mr. VIVIAN. The final part of this question is that presently scientific activities require about 15 percent of the Federal budget. Earlier this morning I spent some time at Goddard Space Flight Center. There is a concentration of dollars per cubic inch out there which is rather enormous. Do you have any view of what percentage you think will be spent in these areas 10 to 20 years from now?

Dr. HAWORTH. No.

Mr. VIVIAN. I don't myself. I am curious.

Dr. HAWORTH. I certainly don't know. However, most of the rest of members of this subcommittee heard me say about 2 years ago that we must think of this in two distinct facets. One is that most of this $15 billion just happens to be science, and the applications of science. It is really the pursuit of national goals. Defense is a prime example. I am now speaking of development and applied research that verges on development, where things are done not in a basic sense but because we need a weapon or a piece of equipment. I don't really think one should refer to a $15 billion package for research, any more than one should think of an x billion dollar expenditure for law or for the practice of economics. Most of the $15 billion package is a means to an end, not a scientific end but a national goal, such as the country's defense.

On the other hand, underlying these means to achieve national goals is the generality of science, both basic and applied research and science education. I think that for these—it is reasonable to think of a total package, and I think it will grow. Clearly it can't grow relatively faster than the gross national product indefinitely, any more than anything else can, because we can't have science constitute half the gross national product or something like that. But I think it will grow.

The big expenditures for development, I suppose, will come and go as goals change, as needs change. If Mr. Foster and Mr. Tsarapkin are successful in disarmament negotiations in Geneva in x years, why this could change the picture tremendously, of course.

So I just don't see any way to predict that sort of thing.

Mr. VIVIAN. Do you feel that the present 15-percent figure is likely to decrease significantly?

Dr. HAWORTH. I don't foresee that, unless something drastic happens.

Mr. VIVIAN. Thank you, very much.

Mr. DADDARIO. Dr. Haworth, many of these questions lead to an increasing role for the National Science Foundation.

In your answers, you refer to the fact that you can only fund a certain number of the projects which are proposed to you. Your project support budget for basic research for the fiscal year 1966 is estimated at $155 million, and you say the estimated amount to require reasonable support for all good proposals would be closer to $280 million. You add to that an unknown figure, since many people do not submit proposals who probably could have submitted proposals. Then as the mission-oriented agencies become restricted by funding, they look to NSF to do more. This gets us to the point where you, as Director, have a great responsibility to handle this as it develops.

Reorganization Plan No. 5 gives you, as the Director, the authority to delegate appropriate authorization of performance to any other officer. What are your plans in this regard? What do you have in mind, if you have reached the point where you could give us some of your thoughts?

Dr. HAWORTH. Well, I haven't got it all completely crystallized, but there are two or three facets to it. One reason for the reorganization plan was to get clearly stated something that we all knew was the intent of Congress, or thought we knew, with respect to my authority to delegate things, for example, to the Deputy Director. The Deputy Director is provided for in the statute.

During the last several years of his directorship, Dr. Waterman didn't have a Deputy Director. There was a very heavy load on him—he signed all the grants, for example.

I have had Dr. Wilson do a major portion of that. I say we share it, but he carries the horse and I carry the rabbit with respect to that activity.

And incidentally, this is authority delegated to me by the Board. There didn't seem to be any problem about my delegating down the line things that are vested in me by the act.

Mr. DADDARIO. You said in your answers to the questions, "including functions delegated to him by the National Science Foundation."

Dr. HAWORTH. Yes. There are a great many grants, for example, that are rather picayune in terms of dollars. I don't mean they are unimportant.

For example, we give a great many travel grants and there are other grants that are just a few thousand dollars, and so on. I plan, although I haven't worked it all out, to delegate some of that sort of thing to the Associate Director level. And there are various day-to-day things of other sorts that I would like to delegate to that level, and they, in turn, then, will be able to delegate some of the things that they do down to the division directors. It is not any very major—it is not going to be an upheaval in the Foundation or anything of that sort. But it just makes it possible to operate in a way, or let's say we no longer are forced to operate in a way that was quite appropriate when the Foundation was small, but not now when it is in the half-billion dollar league—and I am very much opposed to signing a piece of paper that is laid in front of me without studying and understanding it. The fellow that made the decision is the fellow that lays it in front of me, and there is no point in my trying to pretend that I made the decision, and therefore am approving something if I really took no part. I won't do it, as a matter of fact. I always

read everything I sign. And this gets to be impossible for Dr. Wilson and me to do, as the Foundation grows.

I was smiling, when you started your question Mr. Chairman, because you said, "These questions lead to" and I thought you were going to say "a lot more questions."

Mr. DADDARIO. Well, I must admit, Dr. Haworth, that every time you come before us you have, in fact, pointed the way to other questions. This is not an exception, but it can't go on forever. We are at the end of the formal part of our hearings. I must ask you to bear with us as we prepare a few more questions for you. I assure you that they will be very few.[1]

I know we are going to have some activity on the floor, so we will not continue any further. I do want to give you time for your concluding statement. You have already, as I recall it, eliminated 1 minute 15 seconds from your 5 minutes, and then I may have a couple of things to say.

Dr. HAWORTH. Okay.

I think you can guess what I am going to say, and I will repeat some things that I said earlier, just to give a more complete picture.

I want to conclude by saying what I think about the worthwhileness of these hearings. I think they have been of very great value. As I said earlier, they have made us think. I hope they have been informative to you. They have made us think ahead of our daily problems, which we tend to get immersed in all the time.

They have helped, I hope, to give you a broader picture and understanding of the Foundation, of its objectives, of its programs and of its problems, and, in turn, as you said, to other Members of Congress and to the public at large. You have certainly marshaled a wide spectrum of witnesses who have been able to speak of the Foundation from a great many different angles and points of view and differing experiences, and so on, which I think has been a very good thing.

Your questions have been very searching, but always very sympathetic, and we deeply appreciate that.

You, Mr. Chairman, and all the members of your committee have shown very great courtesy and understanding in overlooking—and I am speaking personally, now—my own shortcomings and inadequacies in appearing before you, and I am very deeply appreciative of it, and thank you, very much.

Mr. DADDARIO. Dr. Haworth, the constant attendance by the members of this committee, and the attention they have paid to this whole review indicates the interest that the Congress, and the country, too, has in the National Science Foundation.

I first want to compliment and thank all the members of this committee for their attention to these hearings over a long period of time. I would also like to thank Mr. Yeager, Dr. Wenk, and all the other members of the staff who have helped us prepare for the testimony as we have gone from day to day.

Finally, I would like to add a very large note of thanks to you, Dr. Haworth, and to the members of your staff, and all of the other witnesses who have been here and who have added so much to these hearings.

[1] The questions referred to, and the witness' response thereto, will be contained in vol. II of these hearings.

We are a long way from the time when we will have analyzed the testimony and come to some objective conclusions and recommendations. This will probably take us until the end of this year, and perhaps into the beginning of next. However, I do think that we have—you, on your part, and we, on ours—gotten together to the point where we have a better understanding. I would hope we might be successful in making an impression as a committee on the other Members of Congress so we can, by gaining their confidence, make recommendations that will be in the best interest of the country and the National Science Foundation.

These hearings have been interesting, exciting, and educational.

You have done your job well in giving us the opportunity to see some of the problem areas which arise, and I want to thank you and the whole staff of the National Science Foundation for their diligence and the hard work they have put into these hearings.

In a sense, as far as the congressional and legislative responsibilities are concerned, the rest is up to us.

Thank you, and, of course, we will be in touch with you.

Dr. HAWORTH. Thank you, Mr. Chairman.

Mr. DADDARIO. The committee will adjourn to the call of the Chair.

(Whereupon, at 12:23 p.m., the subcommittee was adjourned subject to the call of the Chair.)

BIOGRAPHIES

DR. SANFORD SOVERHILL ATWOOD

Home address: 1463 Clifton Road NE., Atlanta, Ga.
Born: December 3, 1912, Janesville, Wis.
Parents: Charles Starr Atwood and Cora Soverhill Atwood.
Wife: N. Elizabeth Long (August 15, 1936); children: Charles Starr, Elizabeth Ann, Phoebe Ellen, Richard Jay.
Education: A.B., A.M., University of Wisconsin, 1934; Ph. D., University of Wisconsin, 1937.
Chronological list of positions:
U.S. Regional Pasture Research Laboratory, State College, Pa., 1937–44;
Associate professor, Department of Plant Breeding, Cornell University, Ithaca, N.Y., 1944–45;
Associate professor, ibid., 1945–48;
Professor, ibid, 1948–63;
Head of department, ibid., 1949–53;
Dean of Graduate School, Cornell University, 1953–55;
Provost, ibid., 1955–63; and
President, Emory University, Atlanta, Ga., 1963– .
Fraternities: Phi Eta Sigma, Phi Kappa Phi, Phi Beta Kappa, Sigma Xi, Phi Sigma, Gamma Alpha, Social fraternity, Alpha Chi Rho.
Learned societies: AAAS; AAUP; Genetics Society of America; American Society of Agronomy; Association of Southeast Biologists.
Membership in—
Board of directors, Salzburg Seminar;
Board of directors, Alpha Chi Rho Educational Foundation;
Vice chairman, Council of Presidents, University Center in Georgia (1964–65);
Board of directors, Atlanta Chamber of Commerce;
Commission on Plans and Objectives, America Council on Education (1963–66);
Board of Visitors, Freedoms Foundation at Valley Forge;
The Atlantic Council of the United States;
Technical Advisory Committee of the Atlanta-Fulton County Economic Opportunity Authority (term to run until June 30, 1966);
Committee on Economic Development; and
Rapid Transit Study Commission.
Listed in Who's Who, American Men of Science, Presidents and Deans of American Colleges and Universities.

DR. THOMAS F. BATES

Present position: Science adviser, Department of the Interior. Duties include the furnishing of advice and consultation on programs and management of the Department's research and development program, coordination and representation of research and development externally and the general review and evaluation of research to accomplish the Department's mission in natural resources conservation and development. Serves as a member of the Federal Council for Science and Technology and the Interdepartmental Committee on Atmospheric Sciences. Heads U.S. activities of the United States-Japan Cooperation on Natural Resources under the Committee on Trade and Economic Affairs, effective June 1, 1965.
Born: January 2, 1917, Evanston, Ill.
Degrees: B.A., Denison University, 1939; M.S. Columbia University (geology), 1940; Ph. D. Columbia University (geology), 1944.

Positions at the Pennsylvania State University:
College of Mineral Industries:
Instructor, department of mineralogy, 1942–45;
Assistant professor, department of mineralogy, 1945–49;
Associate professor, department of mineralogy, 1949–53;
Director, mineral constitution laboratories, 1950–57; and
Professor of mineralogy, 1943 to present.
University administration:
Assistant to the vice president for research, 1961 to present;
Director, Institute for Science and Engineering, 1963 to present;
Assistant dean for programs, graduate school, October 1964 to present.

Other organizations served in a consulting capacity (former): C. K. Williams & Co., New York and Pennsylvania company, Sun Oil Co., Carter Oil Co., Shell Oil Co., Georgia Kaolin Co., Kerr-McGee Oil Industries, Pacific Uranium Co., International Minerals & Chemical Corp.

Memberships: Fellow, Geological Society of America; fellow, American Mineralogical Society; American Crystallographic Association; Electron Microscope Society of America; Mineralogical Society of London; American Association for the Advancement of Science.

Fields of research:
X-ray and electron microscope studies of clays and other minerals;
Electron microscope studies of glass and various geological materials;
Mineralogical investigations of fine-grained rocks;
Mineralogy, petrology, and chemistry of uranium-bearing shales and lignites in Tennessee, South and North Dakota, California, and Florida;
Studies of rock weathering and clay formation in Hawaii, California, Pennsylvania, North Carolina, and Georgia.

Résumé of duties at the Pennsylvania State University:
As professor of mineralogy: Teaching of one graduate course;
Principal investigator of two NSF-sponsored research programs;
Supervisor, three Ph. D. candidates;
As assistant to the vice president for research: Concerned primarily with grants and facilities program of the university, dispersal of research funds, development and support of all-university research programs.
As director of the Institute for Science and Engineering: In charge of eight interdisciplinary research units as follows: Center for Air Environment Studies, Computation Center, Institute for Research on Human Resources, Institute for Research on Land and Water Resources, Laboratory for Research on Animal Behavior, Laboratory for Human Performance Research, Materials Research Laboratory, and Ordnance Research Laboratory.
As assistant dean for programs of the graduate school: Concerned with the development and administration of graduate academic programs of an interdisciplinary nature (e.g., solid state technology, acoustics), and with all activities such as fellowship programs, facilities, etc., that require liaison between the research and graduate school offices.

DR. NYLE C. BRADY

Dr. Nyle C. Brady is Director of Science and Education in the U.S. Department of Agriculture. He serves as the Secretary's chief science officer and coordinates the research and education activities of the Department. As a member of the Federal Council for Science and Technology, he participates in the coordination and planning of Government-wide research.

Dr. Brady attended elementary and secondary schools in Manassa, Colo. He holds a B.S. degree from Brigham Young University, Provo, Utah, and a Ph. D. in agronomy from North Carolina State College, Raleigh, N.C.

Following receipt of his Ph. D. in 1947, he became an assistant professor of soil science at Cornell University, Ithaca, N.Y. In 1950 he was promoted to associate professor; 1952—Professor; 1955–63 served as head of the department of agronomy; 1959 (on 7 months leave) served as assistant to the Director of Agricultural Relations, Tennessee Valley Authority.

Dr. Brady has been on five missions to the Philippines—the most recent involving a cooperative education project financed by the Ford and Rockefeller Foundations. He has also visited Taiwan, Vietnam, Honduras, the Soviet Union, and Rumania.

He was president of the Soil Science Society of America in 1964, is a member of the American Society of Agronomy, the American Association for Advancement of Science, American Institute of Biological Science, Rotary International and Sigma Xi. At the Eighth International Soil Science Congress in Bucharest he was appointed Vice President of Commission IV of the International Society of Soil Scientists.

Dr. Brady served about 4 years as editor in chief of The Proceedings which is the official publication of the Soil Science Society of America.

He is coauthor of perhaps the most widely used textbook on soil science, "The Nature and Properties of Soils."

His major research interests are in plant nutrition especially as related to root zone temperatures.

He was born in Manassa, Colo., October 25, 1920, married the former Martha Cornum of Sanford, Colo., and they have two sons and two daughters.

Dr. Brady served in the U.S. Army 1945–46.

DR. HARVEY BROOKS

A native of Cleveland, Ohio, Brooks received his bachelor's degree in mathematics from Yale in 1937. After a year as a Henry fellow studying mathematical physics at Cambridge University, he came to Harvard, where he received his Ph. D. in physics in 1940. In 1940 he was elected for a 3-year term as junior fellow in Harvard's Society of Fellows, but took leave of absence from this appointment after about a year to enter warwork, and never completed his term.

During World War II Brooks served as a staff member of the Harvard Underwater Sound Laboratory directed by Prof. F. V. Hunt. Here he was concerned first with the development of basic techniques for what later became known as scanning sonar and later with the design and construction of a prototype of the first U.S. acoustic homing torpedo, an antisubmarine weapon which saw service in the latter part of World War II. In 1945 Brooks moved with the torpedo project to help set it up at the Ordnance Research Laboratory at Pennsylvania State College. He served for a year as Assistant Director of this Laboratory under Dr. Eric A. Walker.

In 1946 Brooks moved to Schenectady to join the research laboratory of the General Electric Co., where he organized a small theoretical physics group which later became the nucleus of the Knolls Atomic Power Laboratory. Shortly after the establishment of this laboratory Brooks became its associate head under Dr. K. H. Kingdon. The Knolls Atomic Power Laboratory worked on the development of technology for sodium cooled intermediate energy spectrum power reactors. The experience which Brooks gained in Schenectady resulted in a continuing interest in reactor technology, even after his move to Harvard as Gordon McKay professor of applied physics in 1950 resulted in a shift of interest to solid state physics.

Since 1950 Brooks' major research interest has been in solid state theory. In collaboration with others he has worked on the interpretation of the behavior of semiconductors at high pressures. He has published papers in the field of radiation effects on solids, and on various aspects of the quantum theory of solids, as well as on some aspects of nuclear reactor theory. In 1960 he was one of the first five recipients of the Ernest Orlando Lawrence Award of the Atomic Energy Commission in recognition of his work on the theory of fast reactors and in the field of reactor safety. Recently he has become concerned with the relations between science and public policy and has published several papers in this area.

Brooks has served as consultant to numerous industrial organizations and on many Government committees. His Government service includes the Undersea Warfare Committee of the National Research Council, the Advisory Committee on Reactor Safeguards of the Atomic Energy Commission, the Naval Research Advisory Committee, the President's Science Advisory Committee, and the National Science Board.

In 1956 Brooks founded the international journal Physics and Chemistry of Solids, and has remained its editor in chief ever since. In 1961 he was elected to the American Philosophical Society and in 1962 to the National Academy of Sciences. He has been a fellow of the American Academy of Arts and Sciences since 1950. In 1965 he became Chairman of the Committee on Science and Public Policy of the National Academy of Sciences and also Chairman of the Engineering Section of the National Academy.

He is a trustee of the Woods Hole Oceanographic Institution, Smith College, Case Institute of Technology, and is a director of Raytheon Co. He holds honorary D. Sc. degrees from Union College (1962), Yale University (1962), Kenyon College (1963), Harvard University (1963), and Brown University (1964).

Brooks is married and has four children; he and his family live in Cambridge.

DR. BRYCE CRAWFORD, JR.

Bryce Crawford, Jr., was born in New Orleans, La., and grew up mostly in the San Francisco Bay region and in southwestern Texas. His college and university years were spent at Stanford, where he received the A.B. in 1934; the A.M. in 1935; and the Ph. D. in chemistry in 1937. He then spent 2 years at Harvard University as a national research fellow working in the laboratories of Prof. Bright Wilson, Jr.; following this he spent a year at Yale University as instructor in chemistry. Then in 1940 he moved to the chemistry department at the University of Minnesota, which has been his home base ever since; he is now professor of physical chemistry at Minnesota and dean of the graduate school here.

During the war years he was engaged in research on rocket propellants under the OSRD program, carrying out research both in his own laboratories at Minnesota and in the Allegany Ballistics Laboratory at Cumberland, Md. In the main his interests have always centered on molecular spectroscopy and molecular structure.

In 1950–51 he spent some time at the California Institute of Technology and at Oxford University, as a Guggenheim fellow and as a Fulbright fellow at Oxford. He is chairman of the chemistry section of the National Academy of Sciences, and a member of the American Chemical Society, the American Physical Society, the Optical Society of America, the Coblentz Society, and the National Academy of Sciences. He has also served as chairman of the Council of Graduate Schools in the United States.

DR. BOWEN C. DEES

Born: Batesville, Miss., July 20, 1917.
Marital status: Married, one child.
Education: A.B., Mississippi College, 1937; Ph. D., New York University, 1942.
Experience:
- Academic:
  - Graduate assistance, New York University, 1937–42;
  - Instructor (physics), New York University, 1942–43;
  - Professor (physics), Mississippi College, 1943–44;
  - Massachusetts Institute of Technology Radar School staff member, 1944–45;
  - Assistant professor of physics, Rensselaer Polytechnic Institute, 1945–47.
- Federal Government:
  - Physicist, Scientific and Technical Division, General Headquarters, Supreme Commander for the Allied Powers, Tokyo, 1947–50;
  - Division Chief, Scientific and Technical Division, General Headquarters, Supreme Commander for the Allied Powers, Tokyo, 1950-51;
  - Program director for fellowships, National Science Foundation, 1951–56;
  - Deputy Assistant Director for Scientific Personnel and Education, National Science Foundation, 1956–59;
  - Assistant Director for Scientific Personnel and Education, National Science Foundation, 1959–63;
  - Associate Director (Scientific Personnel and Education), National Science Foundation, 1963;
  - Associate Director (Planning), National Science Foundation, 1964—.

Organization membership: American Association for the Advancement of Science, American Association of Physics Teachers, American Physical Society, American Society for Engineering Education, American Society for Public Administration, and Society of Sigma Xi.

WILLIAM A. DOUGLASS

William A. Douglass is president of Careers, Inc., a firm which he founded in 1951 while a senior at Yale.

It was during his junior year that, as vice chairman of the Yale Daily News, he teamed with other student officers of that newspaper to put together a job guide about American industry. Their own difficulty in tracking down accurate and complete job information provided the impetus for the project. Each business firm provided a full-page story of their opportunities for college seniors in the current year. The result was published in the form of a book titled "Career: for the College Man," and was distributed without cost to 22,000 seniors in northeastern colleges. The employers underwrote all costs.

Except for a brief stint with the Central Intelligence Agency in Washington after graduation, Mr. Douglass has been with Careers, Inc. ever since. Until 1954, he represented the company in the Midwest, moving to New York upon his appointment to the presidency.

Under Mr. Douglass, Careers has developed a broad capability in recruiting services. The original college publishing program went national in coverage in 1952 and added special editions for the military reservists in 1958. More than 2 million copies of successive annual editions have now been circulated. A second area of concentration has been the recruitment of engineers and scientists. Careers' continuing programs in this area have made it by far the largest professional recruitment service in America.

The matching of men and jobs calls for very sophisticated communications systems. In 1958 Careers set up a register for its engineering and scientific candidates modeled along the lines of work accomplished at the National Science Foundation. In 1960 the company inaugurated a new concept in job interviewing, organizing groups of companies into a nationwide tour offering engineers and scientists interview sessions in major metropolitan areas. An instantaneous success, these sessions called career centers, have continued on as often as a once-a-week basis ever since.

The accumulation of résumé data on thousands of people who are either seeking their first job or who are seeking a change of job provides Careers with a wealth of research material for the better understanding of the manpower market. In addition to his own company's research releases, Mr. Douglass has written numerous articles, particularly in the technical manpower field, and has been a guest lecturer at George Washington University and New York University. He has also consulted from time to time on manpower problems at the behest of various Federal agencies and congressional committees.

Mr. Douglass was born on May 30, 1929, in Lake Forest, Ill. He is the third and last son of Kingman Douglass, at that time a Chicago broker, now with Dillon Read & Co., in New York City, and Helen James Douglass. Before Yale, he attended prep school at St. Mark's School, Southborough, Mass.

DR. HUGH LATIMER DRYDEN

Dr. Hugh Latimer Dryden has been Deputy Administrator of the National Aeronautics and Space Administration (NASA) since its creation by the Congress in October 1958. He is internationally recognized for his scientific contributions to fluid mechanics and boundary layer phenomena, and has been highly honored for his leadership of research and development associated with aeronautics and astronautics. He became Director of Research of the National Advisory Committee for Aeronautics (NACA) in September 1947, and was named Director of NACA in May 1949, serving until it was superseded by NASA in 1958.

Dr. Dryden currently holds a number of posts in addition to his responsibilities for the U.S. civilian space program under NASA. He is a member of several scientific committees advising Government agencies, including the Department of Defense and the military services. He is technical adviser to the representative of the United States to the United Nations Committee on the Peaceful Uses of Outer Space. Dr. Dryden is a consultant to the Science Advisory Committee to the President and a member of the Standing Committee of the Federal Council on Science and Technology. He is also a national delegate to the NATO Advisory Group for Aeronautical Research and Development.

Born in Pocomoke City, Md., in 1898, Dr. Dryden earned a bachelor of arts degree in 1916 and a Ph. D. in 1919, both from Johns Hopkins University in Baltimore, Md. He joined the staff of the National Bureau of Standards in 1918, where he performed his distinguished research contributing to supersonic flight of aircraft and missiles. He became Associate Director of the National Bureau of Standards in 1946, having previously served for a short time as Assistant Director. Throughout World War II, Dr. Dryden served on numerous technical groups and task forces concerned with aeronautics and guided missiles for the Joint Chiefs of Staff, the military services, and NACA. In 1945 he was the Deputy Scientific Director of the AAF Scientific Advisory Board appointed by Gen. H. H. Arnold to prepare a report to guide future Air Force research and development.

Dr. Dryden is home secretary of the National Academy of Sciences; charter member, honorary fellow, and former president of the Institute of Aerospace Sciences; honorary fellow of the Royal Aeronautical Society, the British Interplanetary Society, and the Canadian Aeronautics and Space Institute; fellow of the American Academy of Arts and Sciences; foreign associate members of l'Academie des Sciences de l'Institut de France; honorary member, Hermann Oberth-Gesellschaft; founding member, National Academy of Engineering, National Academy of Sciences; honorary member, the American Society of Mechanical Engineers; and a member of numerous other professional societies and organizations. He is a trustee of the National Geographic Society.

Many honors and awards have come to Dr. Dryden, including the following:

First American to deliver the Wright Brothers annual lecture before the Institute of the Aeronautical Sciences (1938).

Sylvanus Albert Reed Award (1940).

U.S. Army Air Forces' Medal of Freedom (1946), the second highest U.S. award.

Presidential Certificate of Merit (1948).

Order of the British Empire (civilian division) (1948).

Thirty-seventh Wilbur Wright memorial lecture before the Royal Aeronautical Society (1949).

Daniel Guggenheim Medal (1950).

Wright Brothers Memorial Trophy (1955).

Ludwig Prandtl memorial lecture of the Wissenschaftliche Gesellschaft für Luftfahrt (1958).

Career Service Award of the National Civil Service League (1958).

Baltimore City College Hall of Fame (1958).

President's Award for Distinguished Federal Civilian Service (1960).

Elliott Cresson Medal of the Franklin Institute (1961).

Langley Gold Medal of the Smithsonian Institution (1962).

First Th. von Karman lecture before the American Rocket Society (1962).

Rockefeller Public Service Award (1962).

John Fritz Medal (1963).

Gold Medal of the International Benjamin Franklin Society (1963).

First Annual Award Dr. Th. von Karman Memorial Citation (1963).

Dr. Robert A. Goddard Memorial Trophy (1964).

Hill Space Transportation Award (1964).

Honorary degrees:

Polytechnic Institute of Brooklyn (Sc. D., 1949).

New York University (D. Eng., 1950).

Rensselaer Polytechnic Institute (D. Eng., 1951).

University of Pennsylvania (Sc. D., 1951).

Western Maryland College (Sc. D., 1951).

Johns Hopkins University (LL. D., 1953).

University of Maryland (D. Eng., 1955).

Adelphi College (LL. D., 1959).

South Dakota School of Mines and Technology (D. Eng., 1961).

Case Institute of Technology (Sc. D., 1961).

American University (L.H.D., 1962).

Northwestern University (Sc. D., 1963).

Politecnico de Milan (M.E., 1964).

Swiss Federal Institute of Technology (Sc. D., 1964).

Dr. Dryden is married and has three children: a son, Hugh Latimer Dryden, Jr., in Chicago, and two daughters, Mrs. Andrew Van Tuyl in Silver Spring, Md., and Nancy Travers Dryden, Washington, D.C. He and his wife, Libbie, live at 5606 Overlea Road NW., Washington, D.C.

DR. JOHN W. GARDNER

John W. Gardner, president of Carnegie Corp. of New York and of the Carnegie Foundation for the Advancement of Teaching, was born in Los Angeles, Calif., in 1912. He is an honorary fellow of Stanford University where he received his A.B. and M.A. degrees. He received his Ph. D. degree at the University of California and holds many honorary degrees from colleges and universities in the United States and Canada.

Before World War II, Mr. Gardner taught psychology at Connecticut College for Women and Mount Holyoke College.

In 1942, Mr. Gardner joined the Foreign Broadcast Intelligence Service of the Federal Communications Commission where he served as chief of the Latin American Section.

The following year he joined the U.S. Marine Corps and was assigned to the Office of Strategic Services. He served with the OSS in Washington, D.C., Italy, and Austria. At the time of his release from active duty, he held the rank of captain.

Mr. Gardner came to Carnegie Corp. in 1946 as executive associate. He became president in 1955, and the same year was made president of the Carnegie Foundation for the Advancement of Teaching.

He has at various times served as consultant to the U.S. delegation to the United Nations, the Air Force, the Department of Defense, the Agency for International Development, the U.S. Office of Education, and to the White House. He served on the Special Task Force on Education which President Kennedy brought together shortly after his election. He was chairman of the U.S. Advisory Commission on International Educational and Cultural Affairs (1962–64), President Johnson's Task Force on Education (1964), and of the White House Conference on Education (1965). He is a member of the General Advisory Committee on Foreign Aid.

He is a recipient of the U.S. Air Force Exceptional Service Award, and in 1964 was awarded the Presidential Medal of Freedom, the highest civil honor in the United States.

Mr. Gardner is a member of the board of the Metropolitan Museum of Art and the American Association for the Advancement of Science; a director of the Shell Oil Co. and the New York Telephone Co.; and a fellow of the American Psychological Association and of the American Academy of Arts and Sciences. He is a member of the Council on Foreign Relations and the Society of Sigma Xi.

As chairman of the Panel on Education of the Rockefeller Brothers special studies project, he was chief draftsman of the report, "The Pursuit of Excellence." He is the author of the chapter "National Goals in Education" in the report of President Eisenhower's Commission on National Goals ("Goals for Americans") and also wrote the chapter "Can We Count on More Dedicated People?" in the book "The National Purpose." He is the editor of President John F. Kennedy's book "To Turn the Tide." He is the author of the books "Excellence: Can We Be Equal and Excellent Too?" and "Self-Renewal: The Individual and the Innovative Society."

DR. ARNOLD B. GROBMAN

Dr. Arnold Grobman is a native of Newark, N.J., and has had an interest in the biological sciences since childhood. He did his undergraduate work at the University of Michigan and graduate work at the Universities of Michigan and Rochester. He received his Ph. D in zoology in 1943 from the University of Rochester and the following year was an instructor in zoology there. During World War II he worked in mammalian genetics in the Manhattan District at the University of Rochester Medical School. In 1946 he joined the staff of the Department of Biology of the University of Florida as assistant professor and, in 1951, became director of the Florida State Museum, a unit of the university. During this period he spent some time at the Oak Ridge National Laboratory as a research associate and also participated in an extensive study of medical education at the University of Florida.

He has been active in a number of professional organizations and is a member of about 30 professional and honorary societies. He has served as president of the Southeastern Museums Conference, vice president and secretary of the American Society of Ichthyologists and Herpetologists and was the 1964 president of that society. He is president-elect of the National Association of Biology Teachers. He was a founder and chairman of the board of directors of the

Florida Foundation for Future Scientists. He has been a member of the National Research Council, Division of Biology and Agriculture, and the executive committee of the American Institute of Biological Sciences. He is currently serving on the council of the American Association for the Advancement of Science and on the council of the Academy of Zoology (India). He has served as chairman of the committee on training of the American Association of Museums. He is a member of the Commission on Undergraduate Education in the Biological Sciences.

His technical publications are primarily devoted to the geographic distribution and systematics of amphibians and reptiles. He has also written papers concerned with educational aspects of museums, secondary schools, liberal arts colleges, and medical schools and, for a number of years, has contributed frequent reviews to the *Quarterly Review of Biology*.

In January of 1959 he became director of the biological sciences curriculum study, with headquarters at the University of Colorado, which was organized by the American Institute of Biological Sciences to work for the improvement of biological education. During its 6 years of existence the BSCS has prepared new curricular materials for use at the secondary school level. The books and films produced by this study are now in extensive use in American high schools. As part of the curriculum study program, he has traveled widely overseas contributing to changes in biological education in India, Thailand, Japan, Taiwan, the Philippines, England, and the several countries in Central America.

Dr. Grobman will join Rutgers University as dean of the College of Arts and Sciences on September 1, 1965.

DR. LELAND JOHN HAWORTH

Leland John Haworth became Director of the National Science Foundation on July 1, 1963, following Senate approval on May 9, 1963, of his nomination by President Kennedy. Dr. Haworth came to the Foundation from the Atomic Energy Commission where he had served as Commissioner since April 1961. He succeeded Alan T. Waterman, NSF's Director since its establishment in 1950.

Dr. Haworth began his career as a high school teacher in Indianapolis, Ind., in 1926–28 and then served as an instructor in physics at the University of Wisconsin, 1930–37. He was a Lalor fellow in physical chemistry at the Massachusetts Institute of Technology, 1937–38. At the University of Illinois, he was an associate, assistant professor, and professor of physics, 1938–47. From 1941–46, Dr. Haworth was on leave from Illinois working on defense projects at the MIT Radiation Laboratory. He was appointed Assistant Director of Brookhaven National Laboratory in 1947 and Director of the Laboratory in 1948. In 1951, he was named vice president and in 1960 president of Associated Universities, Inc., while continuing as Laboratory Director. From 1959–61, Dr. Haworth was a member of the Board of Directors of the Oak Ridge Institute for Nuclear Studies. He became a member of the Atomic Energy Commission on April 17, 1961.

Dr. Haworth was born in Flint, Mich., on July 11, 1904. He received an A.B. in 1925 and an A.M. in 1926, both from the University of Indiana. He was awarded his doctorate in physics from the University of Wisconsin in 1931. Dr. Haworth was the recipient of D. Sc. degrees from Indiana University and Bucknell University and a D. Eng. degree from Stevens Institute of Technology in 1961. He was also awarded a D. Sc. by the University of Wisconsin in 1962. In 1964 Dr. Haworth received an honorary doctor of civil laws from Union College, Schenectady, N.Y., and a doctor of laws from Rider College, Trenton, N.J.

The list of special scientific committees and project groups that Dr. Haworth has served on include Project Vista, U.S. Army, 1951; the ad hoc committee on combat developments, U.S. Army, 1954; Technological Capabilities Panel of the President's Science Advisory Committee, 1954; member and Chairman of the NSF Advisory Panel on High Energy Accelerators, 1954 to 1961; and Project Atlantis of the U.S. Navy, 1959. He was a member of the board of directors of the American Nuclear Society, 1955–60, and president, 1957–58. He is a fellow of the American Physical Society, American Nuclear Society, and the New York Academy of Sciences. Dr. Haworth is also a member of the Cosmos Club, Sigma Xi, Gamma Alpha, Phi Beta Kappa, and Lambda Chi Alpha. He received a certificate of merit from the President of the United States for his World War II research. Dr. Haworth represents the Foundation on the Federal Council for Science and Technology and the Defense Science Board of the Department of

Defense. Dr. Haworth also serves as a member of the President's Committee on Manpower and as a consultant to the President's Science Advisory Committee.

Scientific specialties which are of interest to Dr. Haworth include the study and research in surface structure of metals, secondary electron emission, low-temperature research, nuclear physics, high energy physics, very high energy accelerators, and electronics. He has written numerous scientific papers and is the author of several chapters of the MIT Radiation Laboratory technical series.

Dr. and Mrs. Haworth, the former Irene Benik, reside at 1600 South Joyce Street, Arlington, Va. Dr. Haworth has two children by his marriage to the late Barbara Mottier Haworth—Barbara Jane and John Paul Haworth. Barbara Jane resides in Arlington, Va., and John Paul is a resident of Redondo Beach, Calif.

DR. EDWARD PENDLETON HERRING

Herring, Dr. (Edward) Pendleton, Social Science Research Council, 230 Park Avenue, New York, N.Y. American Government. Baltimore, Md., Oct. 27, 03; m. 33; c. 2. A.B., Hopkins, 25, Ph. D., 28' hon. A.M. Harvard, 44. Instr. govt., Harvard, 28–37, asst. prof., 37–39, lectr., 39–43 assoc. prof., 43–46, secy., grad. sch. pub. admin., 37–46; exec. assoc., Carnegie Corp., N.Y., 46–48, PRES., Social Sci. Res. Council, 48– . Consultant, Cent. Statist. Bd., 36 U.S. Dept. War, 41–53; Bureau of Budget, 41–44, exec. secy. cmt. records war admin., 42–45, chmn, 45–46; mem. bd. advisers, Army Indust. Col. 44–47; consultant, U.S. Dept. Navy, 45–51; dir. atomic energy group, UN, 46–47. Ed. in chief; 'Pub. Admin. Rev.' 45–47. Mem. bd. dirs., Social Sci. Res. Council, 46– : dir., Woodrow Wilson Found., 50–53, v. pres., 54. V. chmn. cmt. pub. admin., Social Sci. Res. Council, 42–45. Navy citation and distinguished serv. award. Mem. advisory council, human resources res. inst., AF, USA, 49–53. APSA (2nd v. pres., 45; pres. 53); coun. For. Rel.; A.Philos.S; A.Acad.A.&Sc. Group representation before Congress; public administration and public interest politics of democracy.

(American Men of Science, 9th edition.)

REV. THEODORE M. HESBURGH, C.S.C.

Rev. Theodore M. Hesburgh, C.S.C., has been president of the University of Notre Dame since 1952. In addition to his many responsibilities as the head of one of America's leading universities, Father Hesburgh holds several important posts in the interrelated areas of education, science, Government, and public affairs.

By Presidential appointment, Father Hesburgh is a member of the U.S. Commission on Civil Rights, the U.S. Advisory Commission on International, Educational, and Cultural Affairs and the National Science Board. As chairman of the Board's Committee on International Science Activities, he visited the U.S. research centers in the Antarctic and at the South Pole in 1962. By appointment of Pope Paul VI and his two predecessors, Father Hesburgh has served since 1957 as permanent representative of the Holy See to the International Atomic Energy Agency in Vienna. He is president of the International Federation of Catholic Universities and a former president of the Association of American Colleges (1961). He is a trustee of the Rockefeller Foundation and a consultant to the State Department's Policy Planning Council.

For his leadership in American higher education and tireless public service, Father Hesburgh was named by President Johnson to receive the Medal of Freedom, the highest civil honor the President can bestow. The presentation took place at a White House ceremony on September 14, 1964.

Father Hesburgh was appointed 16th president of the University of Notre Dame at the age of 35 in June 1952. His administration has been one of the greatest periods of physical growth and internal academic development in the university's 123-year history. Today he heads an institution with a beautiful campus of 1,000 acres, a distinguished faculty of 523 scholars and artists and a record enrollment of 6,983 students from every State in the Union and 44 foreign countries.

Since Father Hesburgh's elevation to the presidency, Notre Dame has erected 20 major buildings including the 13-story, $9 million Notre Dame Memorial Library which opened in September 1963. Among the newer structures are a $3 million computing center and mathematics building; a $2,200,000 radiation

research building, erected by the U.S. Atomic Energy Commission; a $1,500,000 center for continuing education; Lewis Hall, a $1 million graduate residence for nuns; and the Stepan Center.

The new library, believed to be the largest college library building in the world, was the focal point of a 3-year, $18 million Notre Dame development program which was completed successfully in June 1963. Early in 1964, the university inaugurated its $20 million Challenge II program, earmarking $6,500,000 for faculty development and new academic programs; $5,500,000 for student aid; $5 million for an athletic and convocation center; and $3 million for two undergraduate residence halls. In each of these two major development efforts, Notre Dame received a $6 million matching grant from the Ford Foundation as one of the original five participants in its special program in education.

During Father Hesburgh's presidency a freshman year of studies and a sophomore year of studies were created—the latter Notre Dame's first foreign study program in Innsbruck, Austria. Another will be initiated in Angers, France, in 1966. New curriculums were established in the Notre Dame Law School, the college of arts and letters, and the college of business administration, and a comprehensive self-study was completed in the college of engineering. During the same 13-year period professors' salaries have been increased substantially, and a number of internationally recognized scholars have been added to the faculty. Father Hesburgh has encouraged a marked development of student government at Notre Dame, stressing the importance of personal responsibility in campus life. There has been a steady increase in the number of Notre Dame seniors winning graduate fellowships in nationwide competition. During the years 1960–63, Notre Dame ranked 10th among the Nation's private universities in the number of Woodrow Wilson, National Science Foundation, and National Defense Education Act fellowships won by its students (121).

Throughout his administration Father Hesburgh has reaffirmed Notre Dame's conviction that it is not enough for a university to develop mere professional competence in its students. Consequently, whether educating students in the liberal and fine arts, science and engineering, or business administration and law, Notre Dame endeavors to instill in its students a sense of moral responsibility which they retain throughout life.

Prior to becoming Notre Dame's president in 1952, Father Hesburgh served for 3 years as executive vice president of the university. During 1948–49 he was head of the theology department. He is the author of "Patterns for Educational Growth" and "God and the World of Man," a widely used college text. Several of his major addresses in recent years have been published in "Thoughts for Our Times" and "More Thoughts for Our Times."

Father Hesburgh has been associated with several educational, scientific, and cultural organizations in addition to those previously mentioned. He is a former director of the American Council on Education and currently is a member of the National Commission on the Humanities. He is a trustee of the Carnegie Foundation for the Advancement of Teaching and served as its president during 1963–64. A former vice president of the Institute of International Education, he is a member of its board of directors, having been chairman of its national advisory committee on Africa and head of its national advisory committee for Fulbright grants.

Identified with the international atoms-for-peace program from the outset, Father Hesburgh was for several years a director of the Midwest Universities Research Association, which unites 15 campuses in a project of high-energy physics, and a member of the Policy Advisory Board of Argonne National Laboratory.

Notre Dame's president is a director of the Woodrow Wilson National Fellowship Corp., the Nutrition Foundation, the Freedom Foundation, and Educational Services, Inc., of MIT. He is a member of the Advisory Council of the Institute of European Studies and the advisory boards of the National Students Association and the National Federation of Catholic College Students as well as cochairman of the National Catholic Conference for Interracial Justice.

Father Hesburgh has been an early and enthusiastic booster of the Peace Corps and was instrumental in establishing a Peace Corps unit in rural Chile. A fellow of the American Academy of Arts and Sciences, he holds the U.S. Navy's Distinguished Service Medal and has been honored by 16 colleges and universities in this country and abroad. Institutions which have conferred honorary degrees on Notre Dame's president include Columbia University, Princeton University,

Dartmouth College, Northwestern University, Indiana University, Brandeis University, University of California at Los Angeles, the University of Rhode Island, Temple University, Villanova University, Bradley University, Gonzaga University, Lafayette College, LeMoyne College, St. Benedict's College, and the Catholic University of Santiago, Chile.

Father Hesburgh was educated at Notre Dame and the Gregorian University in Rome where he received a bachelor of philosophy degree in 1939. He was ordained a priest of the Congregation of Holy Cross in Sacred Heart Church on the Notre Dame campus June 24, 1943, by the late Archbishop John F. Noll, of Fort Wayne. Following his ordination, Father Hesburgh continued his study of sacred theology at the Catholic University of America, Washington, D.C., receiving his doctorate (S.T.D.) in 1945. He joined the Notre Dame faculty the same year.

Born in Syracuse, N.Y., May 25, 1917, Notre Dame's president is the son of Anne Murphy Hesburgh and the late Theodore Bernard Hesburgh, an official of the Pittsburgh Plate Glass Co. A brother, James Hesburgh, was graduated from Notre Dame in 1955 and Harvard (M.B.A.) in 1900 and is vice president of the Wheelabrator Corp., Mishawaka, Ind. Father Hesburgh has two sisters, Mrs. Robert O'Neill, Cazenovia, N.Y., and Mrs. John Jackson, Syracuse, N.Y. A third sister, Mrs. Alton Lyons, of Oneida, N.Y., died in 1957.

DR. J. HERBERT HOLLOMON

Degrees: B.S., physics, Massachusetts Institute of Technology, 1940; D. Sci., metallurgy, Massachusetts Institute of Technology, 1946; Ph. D., engineering, Worcester Polytechnic Institute (honorary), 1964; Ph. D., engineering, Michigan Technological University (honorary), 1965.

Relations with education: Instructor, Harvard School of Engineering, 1940–41; adjunct professor, Rensselaer Polytechnic Institute, 1950–62. Adviser: Cornell School of Engineering, 1958– ; Harvard School of Engineering and Applied Science, 1959– ; and Massachusetts Institute of Technology.

Military: Active duty, 1941–46, research, physical metallurgy, Watertown Arsenal, final rank: Major.

Industry: General Electric Co., 1946–52; research, metallurgy, General Electric Research Laboratory, 1952–60; manager, metallurgy and ceramics research, 1952–60; general manager, General Engineering Lab, 1960–62.

Author: Textbook on metallurgy; more than 100 articles in professional journals.

Editor: Technical book series published by John Wiley Co.

Technical societies: Fellow, American Physical Society; former director of metallurgy, Institute for Mining, Metallurgical & Petroleum Engineers (AIME); former trustee, American Society for Metals (ASM); American Association for the Advancement of Science; Society for the History of Technology; and American Society of Mechanical Engineers.

Honorary societies: Sigma Xi, American Academy of Arts and Sciences, National Academy of Engineering (founding member), and New York Academy of Sciences (fellow).

Awards: Leadership, Kappa Sigma Fraternity, 1940; Raymond W. Rossiter Award of the American Institute of Mechanical Engineers; Alfred Noble Award of the Combined Engineering Societies; the Rosenhain Medal, Great Britain's Institute of Metals (first receipient from the United States); Army Legion of Merit; selected as 1 of the 10 outstanding scientists in the Nation by Fortune and by the National Junior Chamber of Commerce, 1954.

DR. DONALD F. HORNIG

Dr. Donald F. Hornig was born in Milwaukee in 1920, the son of C. Arthur Hornig and the former Emma Knuth. In 1943 he married Lilli Schwenk and they have four children, Joanna, Ellen, Christopher, and Leslie.

Dr. Hornig became Special Assistant to President Johnson for Science and Technology on January 24, 1964. He was simultaneously named by the President to be Chairman of the Federal Council for Science and Technology. On January 27, 1964, the Senate confirmed Dr. Hornig as Director of the Office of Science and Technology in the Executive Office of the President. Dr. Hornig also serves as the Chairman of the President's Science Advisory Committee.

A graduate of Harvard University, where he received his B.S. degree in 1940 and his Ph. D. in chemistry 3 years later, he was awarded a Guggenheim grant and a Fulbright scholarship for research at St. John's College, Oxford University, England, in 1954–55, and in the same year was appointed the first Bourke overseas lecturer by the Faraday Society of London.

After receiving his doctorate at Harvard, Dr. Hornig spent a year as a research associate at the Woods Hole Oceanographic Institution. From 1944 to 1946 he was a group leader at Los Alamos Laboratory and in the latter year joined the faculty at Brown as assistant professor. Three years later he became an associate professor and Director of the Metcalf Research Laboratory. He was promoted to the rank of professor in 1951 and the following year became associate dean of the graduate school. Subsequently he was acting dean. He was appointed chairman of his department at Princeton in 1958. Dr. Hornig was the first incumbent of the Donner Chair of Science at Princeton established in 1958 by the Donner Foundation, Inc.

Dr. Hornig has been an associate editor of the Journal of Chemical Physics and is a member of the Editorial Advisory Boards of Spectrochimica Acta and Molecular Physics. He was president, from 1945–47, of Radiation Instruments Co.; chairman of Project Metcalf, Office of Naval Research in 1951–52. He was a member of the Advisory Committee, Office of Scientific Research, U.S. Air Force. In 1959 he was appointed to the Space Science Board of the National Academy of Sciences on which he served until February of 1964. In 1960 he was appointed by President Eisenhower to the President's Science Advisory Committee and was reappointed by President Kennedy in 1961. In late 1960 he served on the Kennedy task force on space to help formulate policy in this field for the new administration.

In 1962–63 Dr. Hornig was a member of the delegation headed by Dr. Hugh Dryden which negotiated the agreement with the U.S.S.R. for cooperation in certain space activities.

Dr. Hornig was elected in 1954 to a 3-year term on the executive committee, Division of Physical and Inorganic Chemistry, American Chemical Society. He is also a fellow of the American Physical Society (member, executive committee, Division of Chemical Physics, and chairman, 1957–58); a fellow of the American Academy of Arts and Sciences, and of the Faraday Society, London. He was elected to the National Academy of Science in 1957 and in 1964 was named a member of the board of overseers of Harvard University. He was elected an honorary member of the Rumanian Academy of Sciences in February 1965.

Dr. Hornig has published about 70 papers in the Journal of Chemical Physics, Journal of the Optical Society of America, Journal of Physical Chemistry, Review of Scientific Instruments, Physics of Fluids, Molecular Physics, Spectrochimica Acta, Discussions of the Faraday Society on molecular and crystal structure, infrared and Raman Spectra, shock and detonation waves, relaxati on phenomena and fast chemical reactions at high temperatures.

In 1964 Dr. Hornig was awarded an honorary LL.D. by Temple University, and an honorary doctor of humane letters from Yeshiva University in New York in March of 1965.

FRANCIS KEPPEL

U.S. Commissioner of Education Francis Keppel, came to the U.S. Office of Education from the position of dean of the Graduate School of Education, Harvard University. He served in that capacity from 1948 until his appointment to the commissionship in December 1962.

During his tenure as Harvard's dean of the graduate school of education, Mr. Keppel served in numerous advisory and consultant capacities on the national and international scene, including an educational commission for the Nigerian Government in 1960. As Commissioner of Education he is a member of the U.S. National Commission for UNESCO and of the Board of Foreign Scholarships, and served as Deputy Chairman of the U.S. Delegation to the Third Inter-American Meeting of Ministers of Education, Bogotá, Colombia, in August 1963.

Mr. Keppel was born April 16, 1916, in New York City where his father, the late Frederick P. Keppel, was dean of Columbia College and later president of the Carnegie Corp. He received his A.B. degree from Harvard in 1938 and studied sculpture for a year at the American Academy in Rome.

Mr. Keppel continued his studies while serving as an assistant dean at Harvard College from 1939 to 1941. During World War II, he was secretary of the Joint Army and Navy Committee on Welfare and Recreation (1941–44); he served in the U.S. Army 1944–46, rising from private to 1st lieutenant. He then returned to Harvard where for the next 2 years he was assistant to the provost prior to being named dean of the graduate school of education. In the latter capacity, he directed programs for the preparation of school teachers, administrators, and other educational specialists, and guided research activities.

Mr. Keppel is a fellow of the American Academy of Arts and Sciences. He was married in 1941 to Edith Moulton Sawin. They have two children, Edith Tracy (Mrs. Samuel S. Drury, Jr.) and Susan Moulton.

DR. CHARLES KIMBALL

Dr. Charles Kimball has been president of Midwest Research Institute since June of 1950. MRI is an independent, not-for-profit organization with a staff of 350 persons engaged in contract research and development in chemistry, economics, physics, engineering, biology, and related science and technology programs for industrial and government sponsors.

Dr. Kimball is a native of Boston. After undergraduate work in electrical engineering at Northeastern University, he received his master's and doctor's degrees from Harvard University. He has received honorary degrees from Northeastern, Park College, and Parsons College.

Before coming to MRI, Dr. Kimball was technical director of the Research Laboratories Division of the Bendix Corp., Detroit. Earlier he was a research engineer for RCA, taught in the Graduate School of New York University, and served as vice president and director of Aircraft Accessories Corp.

Dr. Kimball is a member of the board of directors of Trans World Airlines and of Hallmark Cards, Inc. He is a trustee of the Committee for Economic Development (CED), the Hallmark Foundation, the Menninger Foundation, and the University of Kansas City, and is on the board of regents of Rockhurst College. He is a fellow of the Institute of Electrical and Electronics Engineers, and a member of Tau Beta Pi and the American Association for the Advancement of Science.

He is the author of many articles in scientific journals and in business and management publications. He is an ardent amateur artist and greatly interested in educational opportunities for young people.

DR. JAMES RHYNE KILLIAN, JR.

Dr. James R. Killian, Jr., became chairman of the Corporation of the Massachusetts Institute of Technology on January 1, 1959, after nearly 10 years as president. The period of his presidency was marked by great expansion of the institute, by increasing research, including responsibilities for defense research, and by more emphasis on the humanities and social sciences in the education of scientists and engineers.

For a number of years Dr. Killian has been one of the leading spokesmen in behalf of better schools, the importance of science in liberal education, the strengthening of engineering education, and greater attention to basic research. Speaking as an educator, he has been a protagonist for the advancement of science and engineering as a national goal of prime importance.

From November 1957, to July 1959, Dr. Killian was on leave from MIT, serving as Special Assistant for Science and Technology to President Eisenhower, a key position at a time when government, science, and industry required special leadership in the search for solutions to problems of worldwide importance.

Dr. Killian was born in Blacksburg, S.C., on July 24, 1904, the son of the late James Robert and Jeannette (Rhyme) Killian and a descendent of Andreas Killian, who came from Germany to Pennsylvania and in 1749 emigrated to Catawba County, N.C. His father was a textile manufacturer.

After attending the McCallie School in Chattanooga, Tenn., he studied at Trinity College (now Duke University) from 1921 to 1923, when he transferred to MIT. He was a member of the class of 1926 and received the degree of bachelor of science in business and engineering administration. He remained at the institute to become assistant managing editor of the Technology Review, alumni magazine. He became managing editor in 1927 and served as editor from 1930 to 1939, when he was made executive assistant to the president of MIT, Dr. Karl Taylor Compton.

During World War II, when Dr. Compton was one of the Nation's leaders in the application of science to the war effort, and when MIT was undertaking a number of special Government projects, Dr. Killian carried much of the burden of administering the institute's complex affairs. He was appointed executive vice president in July 1943, and was elected vice president in December 1945. At the age of 45, in April 1949, Dr. Killian became president, and Dr. Compton became chairman, of the corporation.

Under Dr. Killian's leadership, MIT has been active in increasing its financial resources, not only to meet current needs, but also, through long-range plans, to provide for continual advancement in education and research.

A stanch advocate of more general education—more basic science as well as more humanities and social science—in the engineering curriculum, Dr. Killian has contended that the problem is to provide a common core of studies which will contribute toward a man's effectiveness as an individual and a citizen, regardless of his occupation.

Dr. Killian, therefore, consistently supported changes to balance the institute's professional curriculum with such courses, activities, and environment as would give the graduate intellectual depth as well as breadth. He maintained that not only does the scientific environment stimulate first-rate work in social science, but also that the presence of such a program enables MIT to turn out more efficient scientists and engineers and citizens better qualified to serve their fellows.

Early in his administration, the institute, in response to a recommendation of a faculty committee formed at his suggestion, established a school of humanities and social studies. The institute was further helped to play its rightful role in the development of potential leaders for industry when, in 1952, a school of industrial management was established through gifts of $6,250,000 from the Alfred P. Sloan Foundation, Inc. The center for international studies is another important unit of MIT established during Dr. Killian's presidency. These extensions of the MIT program were all contributory to the creation of a new kind of university which Dr. Killian has described as a "university polarized around science".

Dr. Killian has an extensive record of service to the Government. He served from 1956 to 1957 and from 1959 to 1961 as chairman of the board of trustees, and he continues as a trustee of the Institute for Defense Analyses, an organization set up by MIT and four other universities for applying scientific methods and analysis to military problems. He was a member of the Science Advisory Committee of the Office of Defense Mobilization, 1951–57, and when this committee became the President's Science Advisory Committee late in 1957, Dr. Killian became its Chairman and served that post until July 1959. In 1961 President Kennedy appointed him consultant at large to the committee. He was a member of the President's Communications Policy Board, 1950–51; the President's Advisory Committee on Management, 1950–52; the Board of Visitors of the U.S. Naval Academy, 1953–55; the Committee for the White House Conference on Education, 1954–56; and was chairman of the Army scientific advisory panel from 1951–56. In 1960 he served as a member of the President's Commission on National Goals. Dr. Killian recently retired as Chairman of the President's Foreign Intelligence Advisory Board after 2 years of service. During the Eisenhower administration he served as the first chairman of a similar board.

Dr. Killian was a director of the Federal Reserve Bank of Boston from 1954–57. He is a trustee of the Alfred P. Sloan Foundation, the Mellon Institute, the U. S. Churchill Foundation, Mount Holyoke College, the Boston Museum of Science, the Mitre Corp., and the Nutrition Foundation. He is a member of the board of American Telephone & Telegraph, the Cabot Corp., General Motors Corp. and the Polaroid Corp. Dr. Killian was a member of the board of trustees of the Carnegie Foundation for the Advancement of Teaching from 1957 to 1958. From 1955 to 1958 he served as president of Atoms for Peace Awards, Inc., and he was elected to this office again in 1959. He was moderator of the American Unitarian Association from 1960–61. Also active in his own community, Dr. Killian is a member of the Board of Education of the Commonwealth of Massachusetts and is chairman of the Cambridge (Mass.) Citizens Advisory Committee.

He has been the recipient of a number of honorary degrees: LL. D., Union College, 1947; Bowdoin College, 1949; Northeastern University, 1949; Duke University, 1949; Boston University, 1950; Harvard University, 1950; Williams College, 1951; Lehigh University, 1951; University of Pennsylvania, 1951; University of Chattanooga, 1954; Tufts University, 1955; University of California, 1956;

Amherst College, 1956; College of William and Mary, 1957; Brandeis University, 1958; New York University and Johns Hopkins, 1959; Providence College, 1960; Temple University, 1960; University of South Carolina, 1961; Meadville Theological School, 1962; Sc. D., Middlebury College, 1945; Bates College, 1950; University of Havana, Cuba, 1953; Notre Dame University, 1954; Lowell Technological Institute, 1954; Columbia University, 1958; College of Wooster, 1958; Oberlin College, 1958; University of Akron, 1959; Worcester Polytechnic Institute, 1960; University of Maine, 1963; D. Eng., Drexel Institute of Technology, 1948; University of Illinois, 1960; University of Massachusetts, 1961; D. Appl. Sci., University of Montreal, 1958; Ed. D., Rhode Island College, 1962; HH. D., Rollins College, 1964.

Dr. Killian received the President's Certificate of Merit in 1948; the Certificate of Appreciation, Department of the Army, 1953; and the Decoration for Exceptional Civilian Service, Department of the Army, 1957; the Public Welfare Medal of the National Academy of Sciences, 1957; Officer, French Legion of Honor, 1957; the Gold Medal of the National Institute of Social Sciences, 1958; World Brotherhood Award of the National Conference of Christians and Jews, 1958; Award of Merit of the American Institute of Consulting Engineers, 1958; Washington Award, Western Society of Engineers, 1959; Distinguished Achievement Award, Holland Society of New York, 1959; the Gold Medal of the International Benjamin Franklin Society, 1960; and the Good Government Award, Crosscup-Pishon Post, American Legion, 1960; Hoover Medal, 1963. He was elected honorary member of the American Society for Engineering Education in 1963. A fellow of the American Academy of Arts and Sciences, and Overseas Fellow of Churchill College, England. Dr. Killian is also a member of Sigma Chi and an honorary member of Phi Beta Kappa and Tau Beta Pi. His clubs include the Metropolitan (Washington), the Club of Odd Volumes, St. Botolph, Union and Algonquin (Boston), the Century (New York City) and the University (Boston, New York City).

Dr. Killian was married in 1929 to Miss Elizabeth Parks of Asheboro, N.C., a graduate of Wellesley College. They have one daughter, Carolyn (Mrs. Paul R. Staley), and a son, Rhyne Meredith Killian.

WILLIAM T. KNOX

Mr. William T. Knox was born in Social Circle, Ga., on August 24, 1917. He has been with the Esso Research & Engineering Co., of Linden, N.J., since 1938, progressing from research chemist through manager, technical information division, in 1957, to manager, corporate planning, in 1962.

Mr. Knox has been a consultant on technical information matters to the National Science Foundation, the Office of Science and Technology, the Engineers Joint Council, and the Department of Defense.

In September 1964 Mr. Knox joined the staff of the Office of Science and Technology in the Executive Office of the President, assuming responsibility for stimulating development of more effective scientific and technical information systems. His new responsibilities also include broad questions of research management.

Mr. Knox holds several patents and has authored many articles on petroleum engineering and on information research and management.

Mr. Knox, his wife, Celia, and their three children, are residents of Cranford, N.J.

DR. LEONARD A. LECHT

Leonard A. Lecht is director, national goals project, National Planning Association. Ph. D., Columbia University, 1953. Taught at University of Texas, 1949–53, Carleton College, 1953–54. Chairman, Department of Economics, Long Island University, 1954–62. Since 1962, director, national goals project, NPA. Author: "Experience Under Railway Labor Legislation," 1955; (with G. Colm) "Requirements for Scientific and Engineering Manpower in the 1970's," 1964; "The Dollar Cost of our National Goals," 1965. Member, American Economic Association, Phi Beta Kappa, Royal Economic Society.

DR. HOMER E. NEWELL

Dr. Homer E. Newell is Associate Administrator for Space Science and Applications in NASA Headquarters. He was the Director of the Office of Space Sciences from November 1, 1961, until he assumed his present position November 1, 1963. Previously he was Deputy Director, Space Flight Programs.

As head of the Office of Space Science and Applications, Dr. Newell administers the following NASA program areas: bioscience, communication and navigation, lunar and planetary, meteorological, manned space science, grants and research contracts, geophysics and astronomy, and launch vehicles and propulsion.

An internationally known authority in the field of atmospheric and space sciences, he is the holder of the American Rocket Society's Pendray Award for 1958; the 1960 Space Flight Award, granted annually by the American Astronautical Society to the person who contributed most to the advancement of astronautical sciences; and the AMVETS Civil Servant of the Year Award for 1961.

He joined NASA in October 1958 from the U.S. Naval Research Laboratory where he was Acting Superintendent of the Atmosphere and Astrophysics Division. In this position he was also the Science Program Coordinator for Project Vanguard, the U.S. scientific earth satellite program for the International Geophysical Year.

Dr. Newell was born in Holyoke, Mass., and earned both B.A. and M.A. degrees in teaching at Harvard University and a Ph.D. in mathematics at the University of Wisconsin in 1940. He was awarded a doctor of science (honorary) degree by Central Methodist College, Fayette, Mo., on September 6, 1963.

From 1940 to 1944 he was an instructor and later assistant professor of mathematics at the University of Maryland, and a ground instructor in navigation with the Civil Aeronautics Administration from 1942 to 1943. From 1951 to 1958, as lecturer in mathematics for the University of Maryland, Dr. Newell participated in the NRL—University of Maryland off-campus education program by teaching graduate courses in mathematics to NRL and other Government employees.

Dr. Newell joined the Naval Research Laboratory in 1944, and became head of the Rocket Sonde Branch in 1947. In this position, he was in charge of the upper atmosphere research program of the NRL. In 1955 he was named Acting Superintendent of the Atmosphere and Astrophysics Division.

His scientific committee memberships have included the Special Subcommittee on the Upper Atmosphere of the National Advisory Committee for Aeronautics (1947–51), and the Rocket and Satellite Research Panel (formerly Upper Atmosphere Rocket Research Panel) since 1947. He was chairman of the Rocket and Satellite Research Panel in 1959 and 1960. He was a member of the National Academy of Sciences' Panels on Rocketry and the earth satellite program for the IGY, and was chairman of a special committee of the rocketry panel for planning and organizing this country's IGY sounding rocket program at Fort Churchill in Canada. In addition, Dr. Newell serves on several committees and working groups of the Committee on Space Research of the International Council of Scientific Unions, of the International Union of Geodesy and Geophysics, and of the International Scientific Radio Union.

Dr. Newell is the author of numerous scientific articles and seven books ranging from technical works to popular treatments of space science and rockets. He is a member of Phi Beta Kappa, Sigma Xi, and the Cosmos Club. In addition, he holds membership in the following professional societies, American Association for the Advancement of Science (fellow), American Institute of Aeronautics and Astronautics, Research Society of America, and the American Geophysical Union (fellow). He served as president of the Planetary Sciences Section of the American Geophysical Union during the period 1962–64.

Dr. Newell, his wife, and son, Andrew, reside in Washington D.C. They have three married daughters.

HERMAN POLLACK

Mr. Pollack was born in New York City on October 22, 1919. He received his undergraduate degree at the City College of New York and, while holding a fellowship in the department of government at CCNY, did graduate work at Columbia University.

Mr. Pollack began his Government service career in 1941 with the Office of Price Administration where he served in a variety of assignments in the personnel field. Following a period of service in the U.S. Army, Mr. Pollack served with War Shipping Administration and the Foreign Economic Administration.

Since October 1946, Mr. Pollack has served with the Department of State. Among the positions he has held with the Department are: Deputy Executive

Director and Acting Executive Director, Bureau of European Affairs; Executive Assistant, Office of the Assistant Secretary for Administration; Director of the Management Staff; and the Deputy Assistant Secretary of Personnel. He attended the National War College in 1963–64 and was appointed Deputy Director. Office of International Scientific Affairs on September 13, 1964, and Acting Director on January 1, 1965.

DR. DON K. PRICE

Born: Middlesboro, Ky., January 23, 1910.

Education: A.B., Vanderbilt University, 1931; B.A., Oxford University (Rhodes scholar 1932), 1934; B. Litt., 1935; LL.D., Centre College of Kentucky, 1961; Syracuse University, 1962.

Married: Margaret Helen Gailbreath, March 3, 1936; children: Don C., Linda G. (Mrs. Keith S. Thomson).

Reporter, Nashville Evening Tennessean, 1930–32.

Staff, Home Owners' Loan Corporation, 1935–37; Social Security Research Council, 1937–39; Public Administration Clearing House, 1939–53; U.S. Bureau of the Budget, 1945–46; Hoover Commission on the Organization of the Executive Branch of Government, 1947–48; Deputy Chairman, Research and Development Board, U.S. Department of Defense, 1952–53.

Associate director, 1953–54, vice president 1954–58, Ford Foundation.

Dean, Graduate School of Public Administration, Harvard University, 1958– .

Served as lieutenant, U.S. Coast Guard Reserve, 1943–45.

Member, President's Advisory Committee on Government Organization, 1959–61; Committee on Foreign Affairs Personnel (Carnegie Endowment) 1961–63; President's Advisory Panel on Federal Salary System, 1962–63; President's Advisory Panel on a National Academy of Foreign Affairs, 1962–63; Consultant to the Executive Office of the President, 1961– ; Chairman President's Task Force on Government Organization, 1964; trustee, the Rand Corp.; Vanderbilt University; the Twentieth Century Fund; Director, Social Science Research Council.

Author: "City Manager Government in the United States" (with Harold and Kathryn Stone), 1940; "U.S. Foreign Policy, Its Organization and Control" (with W. Y. Elliott and others), 1952, also "The Political Economy of American Foreign Policy," 1955; "Government and Science," 1954; ed., "The Secretary of State" (for the American Assembly), 1960; "The Scientific Estate," 1965.

DR. ISIDOR ISAAC RABI

My name is Isidor Isaac Rabi. I am at present university professor at Columbia University in New York City. I am also consultant-at-large on the President's Scientific Advisory Committee, a member of the Naval Research Advisory Committee, a member of the Board of Trustees of Associated Universities, Inc., for both Brookhaven National Laboratory and the National Radio Astronomy Observatory. I have been the U.S. representative on the United Nations Science Committee since its inception in 1954. This Committee has been responsible for the formulation of the three Geneva Conferences on the Peaceful Uses of Atomic Energy as well as the Conference on the Application of Science and Technology for the Benefit of Less Developed Areas in Geneva in 1963. I am also the U.S. member of the NATO Science Committee, and a consultant to the International Atomic Energy Agency and to the U.S. Atomic Energy Commission.

I am a graduate of Cornell University with a B. Chem., 1919; and of Columbia University Ph. D. in physics, 1927.

I am a fellow of the American Physical Society, president during 1950–51, a member of the National Academy of Science and the American Philosophical Society.

During the war I was an Associate Director of the Radiation Laboratory in Cambridge, Mass. and consultant to the Los Alamos Scientific Laboratory. I was a member of the General Advisory Committee to the Atomic Energy Commission for 10 years and Chairman for 4 years. At present, I am a member of the General Advisory Committee to the Arms Control and Disarmament Agency.

Since the end of the war I have interested myself in the application of the universal nature of science in creating stronger bonds between the United States and the nations of the world in order to further peaceful, equitable solutions to the problems of international tension.

DR. S. DILLON RIPLEY

S. Dillon Ripley, biologist and authority on birds of the Far East, is the eighth Secretary of the 119-year-old Smithsonian Institution.

Following in the Smithsonian's tradition of scholarly leaders, Dr. Ripley was appointed chief executive of the Institution on February 1, 1964, after serving for 4 years as director of Yale University's Peabody Museum of Natural History.

He also has served on the staffs of the Academy of Natural Sciences in Philadelphia, the American Museum of Natural History in New York, and Harvard University.

Self-described as an "old-fashioned naturalist of the Darwin school," Professor Ripley was only 13 when he hiked through western Tibet studying birds. At the age of 17, with his family's help, he constructed a small duck pond, and since that time has spent 34 years in observing and collecting waterfowl.

The Smithsonian Museum of Natural History has among its research collections more than 3,000 birdskins collected by Mr. Ripley on field trips to the South Pacific, Ceylon, India, and Nepal.

Today, at 51 years of age, he has written six books on ornithological studies, including "A Paddling of Ducks," "Search for the Spiny Babbler," "Trail of the Money Bird," and his most recent, "Land and Wildlife of Tropical Asia."

During World War II, Dr. Ripley served as a civilian attached to the Office of Strategic Services (OSS).

A native of New York City and a 20-year member of its famed Explorers Club, he holds degrees from Yale University and Harvard University. In addition to numerous academic honors, he has received decorations from foreign countries, including the Order of the White Elephant from the Government of Thailand.

A member of several distinguished honorary and professional organizations, Dr. Ripley is president of the International Council for Bird Preservation. He also is an officer of the American Ornithologists' Union and serves on the Council of the International Union for the Conservation of Nature and Natural Resources.

Shortly after his appointment as Secretary of the Smithsonian, Dr. Ripley was named by President Johnson to the National Council on the Arts. He also is vice president of the American Association of Museums and a trustee of the Winterthur Museum.

In his post as chief administrative officer of the Smithsonian, Secretary Ripley heads a staff of more than 2,000 employees charged with preserving and interpreting the scientific, historic, and cultural heritage of America.

The Secretary, who describes the Smithsonian as "a company of scholars," envisions the Institution's future role as "a center for research and scholarship." His programs are designed to use the Smithsonian's collections creatively and across disciplinary lines.

"Collections—of which the Smithsonian has millions in its vast museum-gallery complex—should be a tool; they should not rule you," Dr. Ripley has said.

Dr. Ripley is married and the father of three children.

DR. WALTER ORR ROBERTS

Walter Orr Roberts graduated from Amherst College, A.B., in 1938 and received his M.A. and Ph. D. from Harvard University in 1940 and 1943, respectively. He also holds honorary doctor of science degrees from Ripon College, Amherst College, Colorado College, and Long Island University.

From 1940 to 1960, Dr. Roberts was director of the High Altitude Observatory at Climax and Boulder, Colo. During that time, the observatory evolved from a one-man operation, affiliated with the Harvard College Observatory and the University of Colorado, to a research division of the National Center for Atmospheric Research (NCAR). Since 1960, Dr. Robert has been the director of NCAR and principal officer of its governing body, the University Corp. for Atmospheric Research, a 21-university, nonprofit corporation.

Dr. Roberts also held the following academic appointments: Instructor, Harvard University and Radcliffe College, 1947–48; associate of the Harvard College Observatory, 1948– ; professor of astrogeophysics, University of Colorado, 1957– , (currently on indefinite leave).

His memberships in professional societies include: American Astronomical Society, International Astronomical Union, American Geophysical Union (fellow), Royal Astronomical Society (fellow), American Meteorological Society,

American Institute of Aeronautics and Astronautics, and International Academy of Astronautics of the International Astronautical Federation.

Memberships in other societies include: Sigma Xi, American Academy of Arts and Sciences (fellow), and Aspen Society of Fellows of the Aspen Institute for Humanistic Studies.

Dr. Roberts is a member of the following boards and committees:

Advisory Committee of the World Meteorological Organization;

Inter-Union Commission on Solar-Terrestrial Relationships (ICSU);

Solar Physics Subcommittee of the Space Science Steering Committee of NASA;

Pacific Science Board of the National Academy of Sciences;

Geophysics Research Board of the National Academy of Sciences;

Advisory Committee on Atmospheric Water Resources, Bureau of Reclamation;

Board of directors, American Association for the Advancement of Science;

Panel 3 (scientific investigation of the Pacific Ocean), United States-Japan Committee on Scientific Cooperation;

AAAS Committee on the Public Understanding of Science (chairman);

Trustee of the MITRE Corp.;

Trustee of the Charles F. Kettering Foundation;

Trustee of Amherst College;

U.S. National Commission for UNESCO;

Board of directors, Fund for Overseas Research Grants and Education, Inc.

Present and past services include:

Editorial advisory board, Journal of Planetary and Space Science, 1958– ;

Associate editor, Journal of Geophysical Research, 1960–64;

Chairman, Solar Technical Panel of the U.S. National Committee for IGY, 1957–60;

Director, World Data Center A for Solar Activity, 1957–61;

Chairman, Colorado Weather Control Commission, 1958–60;

Member of Council, American Astronomical Society, 1960–63;

Member of Council, American Meteorological Society, 1960–63;

Member, ad hoc Committee on International Programs in Atmospheric Sciences and Hydrology of the National Academy of Sciences during 1962–63.

DR. JOHN E. SAWYER

Sawyer, John E(dward), coll. president; born Worcester, Mass., May 5, 1917; s. William Henry and Dorothy (Winslow) S.; A.B. Williams College, 1939; A.M. Harvard, 1941; LL.D. Amherst, Clark University 1961, Wesleyan University 1962, Middlebury College 1964; m. Anne W. Swift, June 28, 1941; Children—Katharine, John, Stephen W., William Kent. With Dept. State 1946; jr. fellow Soc. of Fellows, Harvard 1946–49; asst. prof. econ. history 1949–53; assoc. prof. econ. history Yale 1953–61; pres. of Williams College 1961– . Trustee Williams College; Ensign to lieutenant USNR 1942–46; with O.S.S. Washington and overseas; 1942–45; Recipient Bronze Star medal; Mem. Am. Hist. Assn.; Am. Econ. History Assn. (Trustee 1956–60) Am. Econs. Assn.; Phi Beta Kappa, Author articles profl. jours.; Home: 212 Main Street, Williamstown, Mass.

(From: Who's Who in America, vol. 33, 1964–65.)

DR. GLENN THEODORE SEABORG

Dr. Glenn T. Seaborg was born in Ishpeming, Mich., on April 19, 1912, a son of H. Theodore and Selma Erickson Seaborg. At the age of 10 he moved with his family to Home Gardens, Calif., now a part of South Gate, near Los Angeles. From 1925 to 1929 he attended David Starr Jordan High School in Los Angeles, graduating in 1929 as valedictorian of his class. It was in high school that Dr. Seaborg's interest in chemistry and physics was kindled by his science teacher, the late Dwight Logan Reid.

Dr. Seaborg entered the University of Califronia at Los Angeles in 1929. He was elected to Phi Beta Kappa, national honorary scholastic fraternity, in his junior year and received a bachelor of arts degree in chemistry from the university in 1934. In 1934 he entered the University of California at Berkeley where he received the degree of doctor of philosophy in chemistry in 1937. From 1937 to 1939, Dr. Seaborg was a research associate in chemistry on the Berkeley campus, working as the personal laboratory assistant of the late Dr. Gilbert

Newton Lewis, then dean of the college of chemistry, with whom he published a number of scientific papers.

In 1939, Dr. Seaborg was appointed an instructor in chemistry at the University of California, Berkeley. In this post, he became codiscoverer, in 1940, of element 94 (plutonium), the first of a number of transuranium elements which he was to help discover during the next 18 years. He was promoted to assistant professor of chemistry at the university in 1941 and in that year became codiscoverer of the nuclear energy isotope, plutonium 239. Also, in 1941, he helped to discover the uranium isotope U^{233}. In 1942, he was also codiscoverer at the university of the long-lived isotope of neptunium (element 93), neptunium 237 and of the existence in nature of plutonium in extremely small concentrations.

In April 1942, Dr. Seaborg was given a leave of absence from the University of California to head the plutonium work of the Manhattan project at the University of Chicago Metallurgical Laboratory. He remained at the laboratory until May 1946, as chief of the section working on transuranium elements. One of his principal responsibilities there was directing the development of the chemical process which was used for the separation of plutonium from fuel elements irradiated in the production reactors at the Hanford installation at Richland, Wash. While at the laboratory, Dr. Seaborg, with his associates, also discovered two more transuranium elements, element 95 (americium) and element 96 (curium), both in 1944.

In 1945, although still on leave from the University of California, Dr. Seaborg was promoted from assistant to full professor of chemistry at the university's Berkeley campus. In May 1946, he returned to the department of chemistry at the university and also took responsibility for direction of nuclear chemical research at the Lawrence Radiation Laboratory, operated for the Atomic Energy Commission by the university. In 1945 he was named associate director of the Laboratory, a position from which he resigned upon coming to the Commission.

In postwar research, Dr. Seaborg and his colleagues at the university discovered element 97 (berkelium) in 1949 and element 98 (californium) in 1950. In 1952, working with university scientists and scientists of the AEC's Argonne National Laboratory and of the Los Alamos Scientific Laboratory, he discovered element 99 (einsteinium) and, in 1953, element 100 (fermium). He was codiscoverer of element 101 (mendelevium) in 1955 and element 102 in 1958 at the University of California.

In addition to the discovery of transuranium elements, Dr. Seaborg and his colleagues are responsible for the identification of more than 100 isotopes of elements throughout the periodic table. He also is author of the actinide concept of heavy element electronic structure. In this connection, Dr. Seaborg demonstrated that the heavy elements form a "transition" series of actinide elements in a manner analagous to the rare earth series of lanthanide elements. The concept demonstrated how the heavy elements fit into the periodic table and thus demonstrated their relationships to the other elements.

The body of information assembled in Dr. Seaborg's laboratory has made it possible to predict the radioactive characteristics of many isotopes of elements still to be found. Under Dr. Seaborg's leadership, also, whole new bodies of methodology and instrumentation have been developed and have become a cornerstone of modern nuclear chemistry. Dr. Seaborg is the author of approximately 200 scientific papers, including a number of comprehensive reviews and compilations in scientific publications. He is also author and coauthor of several books on chemistry and the elements, including "Education and the Atom" (with D. M. Wilkes), a U.S. presentation volume at the Third International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1964.

Dr. Seaborg was appointed by President Truman in 1946 to be a member of the Atomic Energy Commission's first General Advisory Committee, a post he held until 1950. He was a member of the Joint Commission on Radioactivity of the International Council of Scientific Unions from 1946 to 1956; of the Committee on Standards and Units of Radioactivity of the National Research Council from 1947 to 1951, and of the President's Science Advisory Committee from 1959 to 1961.

Among other honors, Dr. Seaborg was named, in 1947, as one of America's 10 outstanding young men by the U.S. Junior Chamber of Commerce, and in the same year was made recipient of the American Chemical Society's Award in Pure Chemistry. He was awarded the John Ericsson Gold Medal by the American Society of Swedish Engineers in 1948, and the Nichols Medal of the New York

Section of the American Chemical Society, also in 1948. With Prof. E. M. McMillan, of the University of California, he was awarded the Nobel Prize in Chemistry in 1951. He won the John Scott Award and Medal of the City of Philadelphia in 1953, and the Perkin Medal of the American Section of the Society of Chemical Industry in 1957.

Dr. Seaborg was named recipient in November 1959 of the Atomic Energy Commission's Enrico Fermi Award for his outstanding work in the field of nuclear chemistry and for his leadership in scientific and educational affairs. In 1962 he received an award at the semicentennial convocation at Rice University, Houston, Tex., and the Science and Engineering Award of the Federation of Engineering Societies of Drexel Institute of Technology in Philadelphia. He was named "Swedish American of the Year" by the Vasa Order of America in Stockholm, and was presented the Charles L. Harrison Award by the Cincinnati Post, American Ordnance Association in 1962. He received the Franklin Medal, given by the Franklin Institute of Philadelphia, in 1963.

In 1964 he was the first recipient of the Spirit of St. Louis Award, by the University of St. Louis, for pioneering achievements in a field that benefits mankind. Also in 1964 he was presented the Charles Lathrop Parsons Award for public service by the American Chemical Society. In January 1965, he was presented the Leif Erikson Award of the Leif Erikson Foundation of Los Angeles.

Dr. Seaborg is an honorary fellow of the Chemical Society of London and of the Royal Society of Edinburgh. He is a fellow of the American Institute of Chemists, the New York Academy of Sciences, the California Academy of Sciences, the American Physical Society and the American Association for the Advancement of Science. He is also a member of the American Chemical Society, American Nuclear Society, the American Academy of Arts & Sciences, the American Philosophical Society, the American Scandinavian Foundation, the National Academy of Sciences, the Royal Swedish Academy of Engineering Science, the Royal Society of Arts (England), the Society for the Advancement of Scandinavian Study, the American Swedish Historical Foundation, and an honorary member of the Society of Nuclear Medicine.

Honorary degrees awarded to Dr. Seaborg include doctor of science degrees from the University of Denver, 1951; Gustavus Adolphus College, 1954; Northwestern University, 1954; University of Notre Dame, 1961; Ohio State University, 1961; Florida State University, 1961; University of Maryland, 1961; Temple University, 1962; Tulane University, 1962; Drexel Institute of Technology, 1962; Georgetown University, 1962; the University of the State of New York, 1962; Mundelein College, 1963; and Trinity College, 1963; the degree of doctor of laws from the University of Michigan, 1958; and the University of Massachusetts, 1963; the degree of doctor of humane letters from Northern Michigan College, 1962; and Nebraska Wesleyan University, 1964; the degree of doctor of public service from George Washington University, 1962; and the degree of doctor of public administration from the University of Puget Sound, 1963.

In addition to his membership in Phi Beta Kappa, Dr. Seaborg also is a member of Sigma Xi, Pi Mu Epsilon, Alpha Chi Sigma, and Phi Lambda Upsilon fraternities.

Dr. Seaborg was a member of the board of directors, Nuclear Science & Engineering Corp., Pittsburgh, and a consultant for the U.S. Rubber Co. and Bell Telephone Laboratories. He is a member of the advisory board of the Journal of Inorganic and Nuclear Chemistry, a former member of the advisory board of Chemical and Engineering News and of the editorial board of the Journal of the American Chemical Society. He was a member of the board of directors of the National Educational Television & Radio Center, and of the National Committee on America's Goals & Resources of the National Planning Association.

He is chairman of the Steering Committee of the Chemical Education Material Study, sponsored by the National Science Foundation. He became a charter member of the Dag Hammarskjold Fellowship, Inc., in 1962. He also is a member of the Council on the Education of Teachers in Science of the National Science Teachers Association, as well as a member of the Commission on the Humanities of the American Council of Learned Societies, the Council of Graduate Schools, and the United Chapter of Phi Beta Kappa. He is a member of the Advisory Council on College Chemistry of the National Science Foundation.

In August 1958, Dr. Seaborg was appointed chancellor of the University of California at Berkeley. He served in that capacity until his appointment to the Atomic Energy Commission. He is currently considered by the University of California to be on leave from his post as professor of chemistry.

Dr. Seaborg was nominated to the Atomic Energy Commission by President Kennedy on January 21, 1961, and was confirmed by the U.S. Senate on February 24, 1961. He was designated Chairman of the Atomic Energy Commission by the President on March 1, 1961, which is also the date he took the oath of office. He succeeded former Chairman John A. McCone, who resigned as of January 20, 1961. Prior to the expiration of his term on June 30, 1963, Dr. Seaborg was reappointed by the President for a succeeding 5-year term, to expire on June 30, 1968. This appointment was confirmed by the U.S. Senate on June 24, 1963.

Dr. Seaborg served as the representative of the United States to the Fifth, Sixth, Seventh, and Eighth General Conferences of the International Atomic Energy Agency, Vienna, Austria, 1961, 1962, 1963, and 1964. In May 1963, he was chairman of the U.S. delegation to the U.S.S.R. for the signing of the "Memorandum on Cooperation in the Field of Utilization of Atomic Energy for Peaceful Purposes." In August 1963, he was a member of Secretary of State Rusk's delegation to Moscow for the signing of the Test Ban Treaty. In September 1964, President Johnson named Dr. Seaborg as chairman of the U.S. delegation to the Third International Conference on the Peaceful Uses of Atomic Energy, held in Geneva, Switzerland; Dr. Seaborg delivered the summary lecture at this conference.

As Chairman of the Atomic Energy Commission, Dr. Seaborg also serves as a member of the National Aeronautics and Space Council, the Federal Council for Science and Technology, the Federal Radiation Council, and the President's Committee on Equal Employment Opportunity.

On June 6, 1942, Dr. Seaborg married the former Helen L. Griggs, then secretary to the late Dr. Ernest O. Lawrence. The Seaborg's have six children: Peter, Lynne, David, Stephen, John Eric, and Dianne.

Dr. Seaborg's chief hobby is golf. His favorite spectator sport is football, although he follows baseball with interest. From 1953 to 1958 he served as the University of California (Berkeley) faculty athletic representative.

DR. FREDERICK SEITZ

Frederick Seitz was born in San Francisco, Calif., on July 4, 1911. After attending the public schools there, he entered Stanford University and graduated with an A.B. degree in mathematics in 1932. He earned a Ph. D. in physics at Princeton University in 1934 and remained there another year on a research fellowship. Since then he has been successively instructor in physics, 1935–36, and assistant professor, 1936–37, University of Rochester; research physicist, General Electric Co., 1937–39; assistant, then associate professor of physics, University of Pennsylvania, 1939–42; and professor and chairman of the physics department, Carnegie Institute of Technology, 1942–49. In 1949, he was appointed research professor of physics at the University of Illinois and appointed head of the physics department in 1957. He has since been appointed dean of the graduate college and vice president for research, University of Illinois, effective September 1, 1964. In 1962, he began a 4-year term as president of the National Academy of Sciences.

Dr. Seitz's major professional scientific interest has been in the theory of solids and nuclear physics. In addition to numerous review articles and scientific papers, he wrote "The Modern Theory of Solids" (1940) and "The Physics of Metals" (1943), published by McGraw-Hill. He is coeditor of "Preparation and Characteristics of Solid Luminescent Materials," published by John Wiley & Sons in 1948; coeditor of "Solid State Physics" series, Academic Press, Inc.; and author of the chapter on "Fundamental Aspects of Diffusion in Solids" in "Phase Transformations in Solids" (John Wiley & Sons, 1951). He is also a member of the editorial board of Il Nuovo Cimento.

He was a civilian member, National Defense Research Committee, 1941–45; consultant to the Secretary of War, 1945; director of the training program in atomic energy, Oak Ridge National Laboratory, 1946–47; and science adviser to the North Atlantic Treaty Organization, 1959–60. He is now a member, President's Science Advisory Committee; member President's Committee on the National Medal of Science; chairman, Defense Science Board; Department of Defense; member, Advisory Board to the Industrial College of the Armed Forces; member, Naval Research Advisory Committee (chairman, 1960–62), Office of Naval Research; member, Scientific Advisory Group, Office of Aerospace Research; member, Statutory Visiting Committee for the National Bureau of

Standards; consultant, Education Commission of Enquiry, Government of India; chairman, Science Advisory Council of Illinois; member, Policy Advisory Board, Argonne National Laboratory; member, Scientific Advisory Committees, United Aircraft Corp.; and of numerous other advisory and liaison groups.

Dr. Seitz is vice president of the International Union of Pure and Applied Physics; a member, Governing Board of the American Institute of Physics (chairman, 1954–59); member, Council of the American Physical Society (president, 1960–61); member, Board of the Midwestern Universities Research Association; member, Board of Trustees, Rockefeller Foundation; member, Board of Directors, Graduate Research Center of the Southwest; member, Board of Trustees, Education and World Affairs; member, Board of Trustees, Washington Center for Metropolitan Studies; member, Leopoldinian-Carolinian German Academy for Natural Sciences; and corersponding member, Gottingen Academy, Germany.

DR. JAMES A. SHANNON

Dr. James A. Shannon, Director of the National Institutes of Health, has devoted his professional career to medical research. After receiving his medical degree from New York University, he began his research career there and earned his Ph. D. in physiology. By 1940 he had become director of research at Goldwater Memorial Hospital, a medical division of the university.

Dr. Shannon has conducted original research in kidney function, chemotherapy, and malaria. During the war he played a prominent part in malaria research activities of the National Research Council and was a consultant on tropical diseases to the Secretary of War. In recognition of this work, he received the Presidential Medal for Merit, one of the highest awards for civilian service in the Government.

From 1946 to 1949 Dr. Shannon was directer of the Squibb Institute for Medical Research. He became associate director in charge of research for the National Heart Institute in 1949, and associate director of the National Institutes of Health in 1952. He has been Director of NIH since 1955.

In 1965 Dr. Shannon was elected a member of the National Academy of Sciences. Other awards have included the Rockefeller Public Service Award (1964), the Public Welfare Medal of the National Academy of Sciences (1962), and the Mendel Award from Villanova University (1961).

DR. CHALMERS W. SHERWIN

Dr. Chalmers W. Sherwin was born at Two Harbors, Minn., November 27, 1916. He has been an educator, research administrator, and Government official.

He was graduated in 1937 from Wheaton College, Ill., with a B.S., degree and received his Ph. D. in physics from the University of Chicago in 1940. He was an assistant in physics at the University of Chicago in 1941 and a member of the staff of the radiation laboratory of MIT from 1941 to 1945. He was in the physics department at Columbia University in 1946 before becoming assistant professor of physics at the University of Illinois, where he became an associate professor in 1948 and a professor in 1951. He has been with the Aerospace Corp., Los Angeles, Calif., since 1960.

During 1954–55 Dr. Sherwin, on leave of absence from the University of Illinois, served as chief scientist of the U.S. Air Force. Upon leaving that assignment he was awarded the Medal for Exceptional Civilian Service. He has also served various Government agencies as a consultant.

Dr. Sherwin is a fellow of the American Physical Society.

DR. RICHARD H. SULLIVAN

Dr. Richard H. Sullivan, president of Reed College in Portland, Oreg., graduated from Harvard College in 1939, magna cum laude. He received his master's degree in 1940 from the Harvard Graduate School of Arts and Sciences, and served as an assistant in English and chief proctor of dormitories the following year. He was appointed assistant dean of Harvard College in 1941. Following service as an intelligence officer in the U.S. Navy, Dr. Sullivan joined the College Entrance Examination Board in 1946, where he served as assistant director until 1948. He was appointed assistant treasurer of the Educational Testing Service in 1948, becoming executive vice president and treasurer the following year. Dr. Sullivan became president of Reed College in 1956. He was awarded the honorary degrees, doctor of laws by Pacific University in 1960, and doctor of humane letters by Hebrew Union College in 1961.

Dr. Sullivan is active in educational affairs on the national level. He is a member of the U.S. Office of Education's Advisory Committee for Graduate Facilities and the National Science Foundation's Divisional Committee for Scientific Personnel and Education. He is a trustee of the Committee for Economic Development. In 1955, under the sponsorship of the Carnegie Corp., Dr. Sullivan directed a special study which resulted in the formation of the Office of Statistical Information of the American Council on Education. He is a trustee of the College Retirement Equities Fund, elected by policyholders nationally; he has served as a trustee of the American Council on Education, the College Entrance Examination Board, and the Independent College Funds of America.

In Oregon, Dr. Sullivan has chaired a Governor's committee for the establishment of an Oregon Graduate Center for Study and Research. He is a member of the executive committee of the Metropolitan Interfaith Commission on Race and served on the Portland Public Schools' Committee on Race and Education. He has served as a member of the board of directors of the City Club of Portland.

DR. FREDERICK E. TERMAN

Terman, Frederick Emmons, educator, electronics engineer; b. English, Ind., June 7, 1900; s. Lewis Madison and Anna Belle (Minton) T.; A.B. in chemical engineering, Stanford University, 1920, E.E. 1922; Sc. D. in electrical engineering, Mass. Institute of Tech., 1924; Sc. D. (hon.) Harvard University, 1945; University of British Columbia, 1950; Syracuse University, 1955; married Sibyl Walcutt, March 22, 1928; children: Frederick Walcutt, Terence Christopher, Lewis Madison. Instructor to professor electrical engineering 1925–37, prof. and executive head electrical engineering department, 1937–45, dean School of Engineering 1945–58, Provost since 1955, Vice President since 1959, Acting President Feb.–Aug. 1964, Stanford University; dir. Harvard U. Radio Research Lab. (chief U.S. agency developing countermeasures against enemy radar), 1942–45; Mem. Divs. 14 and 15 Nat. Defense Research Com., 1942–45; Decorated by British Government 1946, awarded Medal for Merit, 1948; mem. Special Technical Advisory Group 1950–53, and TAPEC Committee 1953–56 of Dept. of Defense; mem. Signal Corps Research and Development Advisory Committee 1954–62; mem. Advisory Council Army Electronics Proving Ground 1954–57; mem. Naval Research Advisory Committee, 1956–64 (Chmn, 1957–58); mem. Defense Science Board 1957–58; mem. MPE Div. Committee of Nat. Sci. Fndn., 1955–59 (Chmn. 1958–59); Consultant Pres. Sci. Adv. Comm., 1959–; Board of Foreign Scholarships of State Dept. 1960–; Patent Panel, Dept. of Commerce 1963; director, Hewlett-Packard Company, Stanford Bank, Watkins-Johnson Co., Granger Associates; vice chairman, Stanford Research Institute; Trustee, Institute for Defense Analyses; Graduate Research Center of Southwest; SMU Foundation for Science and Engineering; mem. Nat. Acad. Sci. (Chairman Eng. Sec. 1953–56; Council, 1956–59); founding mem. Nat. Acad. Engrg; mem. Am. Philos. Soc; fellow Inst. of Radio Engrs. (director 1940–43, 1948–49, v.p. 1940, pres. 1941, Medal of Honor 1950; Founders Award 1962); Fellow, Am. Inst. of Elec. Engrs. (first recipient Education Medal, 1956), Am. Soc. Engring. Edn. (v.p. and Chairman of Administrative Council), 1949–51; dir. Research Council, 1948–51; Lamme Medal, 1964; Audio Engring. Soc. (hon. mem. 1955); Eta Kappa Nu ("Eminent Member", 1951), WEMA Medal of Achievement 1963. Bohemian Club. Author: Transmission Line Theory (with W. S. Franklin), 1927, Radio Engineering, 1932, 1937, 1947, revised as Electronic and Radio Engineering, 1955; Measurements in Radio Engineering, 1935; Fundamentals of Radio, 1938; Radio and Vacuum Tube Theory (in collaboration with U.S. Mil. Acad. staff), 1940; Radio Engineers' Handbook, 1943; Electronic Measurements (with J. M. Pettit), 1952; Contr. articles in tech. mags.; Consulting Editor, Electronic and Electrical Engineering Series, McGraw-Hill Book Co., Inc.; Home 659 Salvatierra Street, Stanford; Office: Provost's Office, Stanford University, Stanford, California.

DR. MERRIAM HARTWICK TRYTTEN

Born January 7, 1894, Albert Lea, Minn.

Education: 1916, B.A., Luther College, Decorah, Iowa ;1924, M.S., State University of Iowa : 1928, Ph. D., University of Pittsburgh.

Past experience: 1918–19, American Expeditionary Forces; 1917–24, instructor, phys, Luther College; 1920–21, American Scandinavian Foundation fellow, Oslo,

Norway; 1924–41, instructor, assistant professor, University of Pittsburgh; 1941–43, Office of Scientific Research and Development; 1943–44, War Manpower Commission; 1944—, Director, Office of Scientific Personnel, National Academy of Sciences-National Research Council.

Partial list of committees and advisory functions:

Chairman, Civil Service Commission Advisory Committee on Scientific Personnel, 1946–52;

Chairman, Selective Service Scientific Advisory Committee, 1949–52;

Member, Conference Board of Associated Research Councils, 1949—; chairman 1962–63;

Chairman, Committee on International Exchange of Persons (Fulbright program), 1950—;

Vice chairman, Commission on Human Resources and Advanced Training, 1950–54;

Member, Scientific Manpower Commission, 1959—; President 1961—;

Consultant, Engineering Manpower Commission, 1949—;

Consultant to several Federal agencies;

Fellow, American Physical Society.

Member: AAAS, ASEE, Cosmos Club.

Author, books and articles.

Honorary degrees: LL.D., Luther College, 1950; LL.D., St. Olaf College, 1951; D. Sc., Wesleyan College (Conn.), 1951; D. Sc., Carthage College, 1952; D. Sc., Drexel Institute of Technology, 1956; D. Sc., University of Pittsburgh, 1962.

DR. ERIC A. WALKER

Eric A. Walker was born in Long Eaton, England, April 29, 1910, and came to this country as a young boy. He received his bachelor's, master's and doctor of science degrees from Harvard, and holds honorary doctorates from many universities.

As an engineer, he has made significant contributions in the fields of acoustic properties of liquids, high-voltage insulation, and electromagnetic precipitation. During World War II, he helped develop the acoustic homing torpedo, which was instrumental in breaking the submarine blockade. For this and other war research, he won the Naval Ordnance Development Award and the Presidential Certificate of Merit.

He headed the department of electrical engineering at Tufts College, at the University of Connecticut, and at the Pennsylvania State University, where he also directed the Ordnance Research Laboratory. At Penn State he was later dean of the College of Engineering and Architecture, and since 1956 has been president of the university. He has been a member of the Board of Visitors of both the U.S. Naval Academy and the U.S. Military Academy. He was a founder of the National Conference on the Administration of Research, and has held leading positions in many educational associations and commissions at both State and National levels. He has been president of the American Association for Engineering Education, and of the Engineers' Joint Council.

He was a member of the Army Scientific Advisory Panel, Vice Chairman of the President's Committee for Scientists and Engineers, and Chairman of the National Research Council's Committee on Undersea Warfare. He is currently Chairman of the Naval Research Advisory Committee, Chairman of the Board of the National Science Foundation, and a member of the Defense Science Board. He is vice president of the National Academy of Engineering, having been one of the prime movers in its establishment.

Dr. Walker's accomplishments have been widely recognized by many awards and other honors, including the Horatio Alger Award, the American Legion Distinguished Service Medal, and the Tasker E. Bliss Award of the American Society of Military Engineers. He serves as board member of a number of organizations, and is consultant to various industrial companies.

DR. ALVIN M. WEINBERG

Alvin Martin Weinberg, physicist, was born April 20, 1915, in Chicago, Illinois. He holds the A.B. (1935), the A.M. (1936) and the Ph. D. (1939) from the University of Chicago. He was a member of the President's Science Advisory Committee, 1960–62. Dr. Weinberg received the Atoms for Peace Award (1960). He is a member of the American Nuclear Society and the National Academy of Sciences. He is Director, Oak Ridge National Laboratory.

DR. DAEL WOLFLE

Dael Wolfle is executive officer of the American Association for the Advancement of Science, the large, national, membership society that represents all fields of science. He received the bachelor of science and master of arts degrees from the University of Washington, in Seattle, and, in 1931, the doctor of philosophy degree from the Ohio State University.

Prior to World War II he served on the faculties of the Ohio State University, the University of Mississippi, and the University of Chicago. During World War II he was Civilian Training Administrator with the Army Signal Corps and a technical aide in the Office of Scientific Research and Development.

From 1950 to 1954 he was Director of the Commission of Human Resources and Advanced Training. This Commission was established by the National Academy of Sciences and the research councils in education, social science, and the humanities to study the Nation's resources, potential resources, and supply of persons in science, engineering, and the other professions. It made extensive use of data from the Bureau of the Census, the Bureau of Labor Statistics, and the national rosters, and conducted its own special studies of specialized manpower supply and demand.

He is a member of the National Advisory Health Council, the Commission on Graduate Medical Education, and advisory committees to the National Science Foundation; chairman of the Commission on Human Resources and Advanced Education; and a former member of the Defense Science Board of the Department of Defense, of the Scientific Advisory Board of the Air Force, and of advisory bodies to the Office of Naval Research, the Civil Service Commission, the Department of Labor, and other national and international governmental organizations.

INDEX OF PERSONAL NAMES

SUBJECT INDEX

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GOVERNMENT AND SCIENCE

REVIEW OF THE NATIONAL SCIENCE FOUNDATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH, AND DEVELOPMENT

OF THE

COMMITTEE ON
SCIENCE AND ASTRONAUTICS
U.S. HOUSE OF REPRESENTATIVES

EIGHTY-NINTH CONGRESS

FIRST SESSION

VOLUME II

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U.S. GOVERNMENT PRINTING OFFICE
51-204 WASHINGTON : 1965

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CONTENTS

VOLUME II

APPENDIX 1

Summary of Testimony

June 23, 1965

Witness: Dr. Leland J. Haworth, Director, National Science Foundation.

A. Highlights of statement

1. Issue of NSF and Government participation in basic research raised in Academy report and LRS report relate to problems pointed out in last NSF annual report.

2. Increase in Federal funding for R. & D. from $1 billion with $50 million for basic research in fiscal year 1950 to $15 billion and $1.9 billion in fiscal year 1965 has resulted in (*a*) increased tempo in science and (*b*) qualitative improvement of scientific effort.

3. Three objectives of Federal research support: (*a*) to assure maximum scientific and technological preeminence; (*b*) to develop means required for national programs, such as military defense and space, and (*c*) to contribute to benefit of the people.

4. NSF mission: "the advancement of science in the national interest" through "supporting the extension of scientific knowledge and the strengthening of the educational processes leading to such extension."

5. NSF growth and development:

a. Act of 1950 made NSF responsible for promotion of basic research and education in the sciences, and for pursuit of national science policy.

b. Roles of Director and NSB delineated; delegation discussed.

c. Growth of activities:

(1) Early pattern for support of research in universities established by ONR, NIH, AEC, and others prior to NSF.

(2) Early attention to statistical studies and analyses of national R. & D. and questions related to scientific and engineering manpower.

(3) Review by panels by peers.

(4) Project method, "still the Foundation's major means of supporting research."

(5) Graduate fellowships.

(6) Later programs—national research programs, support of research facilities, establishment and support of national research centers, new mechanisms in science education.

d. NSF emphasizes "investment in people as a broad element of the strategic approach to helping science move forward." Discussion of—

(1) Research support to encourage growth in academic research activities;

(2) Increasing research in areas of national interest;
(3) Upgrading quality of science education;
(4) Attracting students to science; and
(5) Stimulating growth of existing and new centers of excellence.

e. Science education:
(1) NSF interested in improvement at all levels.
(2) Programs have three objectives:
(a) Providing advanced training;
(b) Improving quality of course materials and teaching methods; and
(c) Improving science teachers.
(3) " * * * concern in science education is directed primarily at the qualitative aspects" aiming to produce better students and teachers.
(4) NSF a "trail breaker" in experiments to improve learning.

f. Direct funding of academic institutions for (1) graduate laboratories; (2) institutional base grants; and (3) science development grants.

g. Science information program goes beyond basic research. Does not involve large expenditures, but impact is broad. Translation and dissemination of foreign science information, and development, funded by NIH, DOD, and NSF, of high-speed source of chemical information for scientists—a pioneering effort in government interagency coordination in information systems field.

h. Science resources planning:
(1) More than 95 percent of NSF appropriations devoted to support of science and science education; remainder to science resources planning.
(2) Reorganization Plan No. 2:
(a) Director, OST, given NSF's former policy function concerning advising and assisting the President in achieving "coordinated Federal policies for the promotion of basic research and education."
(b) NSF continues to originate policy proposals and recommendations concerning support of basic research and education in sciences, and provides OST with studies and information on which to base national policies in science and technology.
(c) Factfinding and analysis function expanded to perform latter assignment, and resources planning given greatly enhance organizational position. "Now that we have gathered and have at hand a more nearly adequate base of information, we believe we can launch a major effort to isolate particular road blocks and problems in the path of the Nation's scientific development—and thus assist more effectively in the development of policies to assure healthy scientific progress for the country."

*B. Highlights of charts and tables** (*Nos. 1–11*)

1. "Purposes of the Federal Science Complex" (chart 2)—Shows interrelationship between parts of complex.

2. "Executive Branch Science Coordination" (chart 3)—Elementary relationships within the executive branch. "* * * fair to say that OST, Dr. Hornig and his office, look unusually strongly to the NSF for assistance in helping them develop information and policy both for OST and for the Federal Council * * *."

3. "National Science Foundation Activities in support of Science and Science Policy Development" (chart 1)—Schematic of NSF activities.

4. "Funds Used for Research, Development, and R. & D. Plant, by Source of Funds, 1963" (chart 4)—Calendar year 1963 data for Government and non-Government activities. Federal support for development exceeded total research support.

5. "Research and Development, 1963" (chart 5)—Shows source and use of funds. R. & D. plant is not included. Federal Government provided about 65 percent of total spent on R. & D. About a quarter of funds for academic research provided by universities, including public and private support.

6. "Trends in Federal Obligations for Basic and Applied Research, Development and R. & D. Plant" (chart 6)—Shows some of trends in Federal R. & D. from fiscal year 1956 to fiscal year 1965.

7. "Basic Research, 1963" (chart 7)—of $1.8 billion, 58 percent provided by Federal Government, 22 percent by industry, 12 percent by colleges and universities, and 8 percent from private foundations. Data may be distorted by differences in definition of basic research in academic institutions and in industry.

8. "Trends in Federal Obligations for Basic Research, by Field of Science" (chart 8)—Shows trend of Federal support of science and trend of support of various fields.

9. "National Science Foundation as a Source of Funds" (chart 9)—In 1964 NSF provided about 1 percent of all A. & D. funds in country; about 12 percent of all R. & D. at colleges and universities, but roughly 10 percent of all Federal basic research.

10. "Mechanisms of Support" (chart 10)—Shows how NSF programs may serve more than one function. All institutional programs affect both research and science education. Science information has indirect effect.

11. "Distribution of Funds for Direct Support of Science" (chart 11)—Shows where money goes—to colleges and universities, nonprofit organizations, individuals, industry, other Government agencies.

C. Highlights of questioning

1. Geographic distribution of fellowships directed by enabling legislation; applicants ranked in quality groups; selection for geographic distribution at lower levels; no detriment to merit principle of selection because choosing from "substantially equal ability."

2. Proposed limitation on fellowships according to residence would be barrier to selection on merit; and would penalize students for residence rather than ability.

*Charts referred to by Dr. Haworth can be found in vol. I, pp. 13–30.

3. NSF may pick up slack as mission agencies reduce their basic research.

4. R. & D. figures for industry not distorted by charging R. & D. to production. Notes fuzzy definitions of R. & D. in data gathering. Believe industrial data "accurate within a spread of several percentage points."

5. On statistics: "None of these numbers should be taken too literally except the numbers that represent how many checks the U.S. Government did write for something."

6. Science students can obtain support to become teachers through competitive fellowships program—not through education programs for existing science teachers. Preservice teacher training is being discussed; some small experimental programs at present.

7. Re U.S. support of foreign science: "I personally feel that cooperation in science offers one of the few windows that show any real promise of solving some of our really important problems of the world."

June 24, 1965

Witness: Dr. Leland J. Haworth, Director, National Science Foundation.

A. Continuation of discussion of charts

1. "Science Programs Support, fiscal year 1965" (chart-table 12) which comprise about 75 percent to operational funds, 16 percent for facilities.
2. "Table—Science Programs Support" (chart 12–A)—Breaks down NSF research and education totals in detail.
3. "Total Research Program Funds, by Research Areas" (chart 13)—Relative NSF support of research in different fields. Most funds go to mathematical and physical sciences; social science support has highest growth rate, with engineering close behind.
4. "Distribution of Basic Research Project Grant Funds by Type of Expenditure" (chart 14)—Shows representative use of funds for basic research; salary shown separately.
5. "Science Education Programs Support, Fiscal Year 1965" (chart 15)—NSF's science education programs. Course content improvement materials. Noted:

    O. of E.-NSF relations need for careful delineation of functions;

    Existence of "quite close knowledge and cooperation";

    Belief that graduate science education is predominant NSF responsibility;

    At other levels, especially in high school and elementary schools, NSF should be a leader and innovator.
6. "Funds Directed Primarily Toward Support of Science Education" (chart 16)—Step up between 1963 and 1964 due to initiation of traineeship program as result of PSAC recommendations.

B. Highlights of questioning

1. Social science support began with social psychology and gradually expanded to other fields.
2. Establishment of Humanities Foundation welcome. Might be a "fuzzy edge" for social sciences. Humanities Foundation badly needed—would be complementary to rather than competitive with NSF.
3. No fixed proportion of NSF budget for social sciences.
4. Larger representation of physical sciences on NSB, but social sciences "well represented."
5. Re allocation of funds between different fields, criteria are "rather general and vague"—one important criteria is simply what is the situation with respect to good research that is being proposed.
6. Criteria for evaluation: Proven ability of researcher, value and potential productivity of ideas, and proposed course of action.
7. Funds insufficient to support all good research proposed.
8. NSF charter extends only to basic research in engineering.
9. Delineating O. of E. and NSF responsibilities "will require great care." Sensible guidelines from Congress may be helpful.

June 25, 1965

Witness: Dr. Leland J. Haworth, Director, National Science Foundation.

A. Continuation of discussion of charts

1. "Funds Directed Primarily Toward Support of Science Education" (chart 16)—Effect of support at precollege, undergraduate, or graduate level shown.

2. "Support of Individuals Under Selected Science Education Programs" (chart 17)—Since many took part in more than one program, data does not represent total of individuals participating.

3. "Total Fellowship and Traineeship Awards, Fiscal Years 1952–56" (chart 18)—Adverse effect on quality of proposed percentage limitation on fellowship awards by States of residence discussed. Individual or economic need not factors in selection. Breakdown of NSF predoctoral fellowship and traineeship awards, by program and field, Fiscal Year 1965, submitted for record; list of institutions granting Ph. D.'s to be supplied.

4. "Universities and Colleges Receiving NSF Funds in Support of Science, Fiscal Year 1964" (chart 19)—Note, many institutions receive grants in more than one category.

5. "Support Funds Compared With Degrees Awarded and High School Graduations, by Geographic Division" (chart 20)—Distribution of NSF research funds, excluding facilities, among nine geographic divisions. Mentions numbers of doctoral degrees, of other degrees, and of oncoming students as indicators. State financing in central United States appeared higher than for East. Not certain about comparison with west coast. Five of ten universities that get most Federal support are in north-central region: Chicago, Ill., Wisconsin, Minnesota, and Michigan.

6. "Fellowship Awardees, Fiscal Year 1965, Compared With Two Educational Characteristics, by Geographic Division" (chart 21)—Distribution seen as relatively even.

7. "Total Personnel and Scientific Professional Personnel, 1959–65" (chart 22)—What is spent inside NSF for administration. Ratio of operating costs to total obligations has declined slightly.

8. "Projection of Federal Obligations for Basic Research in Universities and Colleges Proper, Fiscal Years 1966–75" (chart 23)—Federal basic research at universities almost $2½ billion by 1975. Present Federal basic research represents half of total Federal R. & D. support to colleges and universities.

9. "Projection of NSF Obligations for Basic Research in Universities and Colleges Proper, Fiscal Years 1966–75" (chart 24)—If NSF

maintained a constant 15 percent of Federal total basic research support, support would grow from $130 million to a little under $540 million.

B. Highlights of statement[1]

1. Increased role for NSF in basic research:

a. Assumes support of basic research in mission agencies to continue.

b. NSF the logical agency to fund major fraction of new and expanding requirements.

c. General agreement in executive branch, in Congress and in scientific community that Federal Government must continue major support of academic research, and provide for appropriate growth.

d. Increased support necessary because (1) many first-rate scientists not now adequately supported; (2) as enrollments expand, increased faculty and graduate students will need support, estimated 8 to 10 percent annual increase, and (3) costs of more sophisticated equipment and additional supporting personnel constantly rising, 5 to 7 percent.

e. Overall increase of 15 percent or more in support of research in academic institutions needed "to hold our own." Matter is under study by a panel of PSAC; NSF providing major support of staff for project.

f. NSF share of basic research calculated for fiscal year 1966 on basis of 15 percent increase, plus shortfall in other agencies estimated at $50 to $55 million.

g. Continuation, strengthening and expansion of national research centers necessary. Project Mohole expected to become a national research center. Centers necessary to advancement of science and to supplement university resources.

2. Nature of NSF support at academic institutions:

a. How to strengthen individual centers of higher education:

(1) Methods of research support:

(a) Project support best, despite disadvantages.

(b) "Judgment by peers" considered best means to evaluate proposals.

(c) Institutional base grants intended to offset disadvantages of project system—(1) lack of flexibility and (2) decreased freedom of action of academic administrators.

(d) NSF planning to broaden base for institutional grants to include total Federal funds to an institution.

(e) Planning more comprehensive research project grants to support groups of individuals from more than one field.

(f) Notes tendency of project system to concentrate research support in a few institutions.

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[1] Dated June 24, 1965: NSF in the Federal science structure of the near and low-range future.

b. How to help build stronger institutions of higher education throughout the country:

(1) Maintain and improve existing centers of excellence.

(2) Assist graduate institutions of recognized ability to develop their potential; build up "pockets of strength" in educational institutions.

(3) Assist younger scientific and engineering faculty members from smaller institutions.

(4) Lift general quality of undergraduate science education.

These courses of action adopted by FCST as guidelines for future. First three apply to all Federal agencies, fourth to NSF alone. Courses of action intended to meet different needs and require different criteria in implementation. Must continue to stress quality and at same time work to develop future ability.

Need to develop simpler and less constraining support of university and college research.

c. Science education:

(1) Need to upgrade quality at all levels and in all fields.

(2) Assure future science teachers are well prepared.

(3) Continue emphasis on science instruction at precollege levels.

(4) Maintain and strengthen ties with O. of E. and all other groups, private and public, supporting programs in science education.

d. NSF leadership called for in—

(1) Promotion of basic research.

(2) Weather modification and science information.

(3) Interdisciplinary problems.

(4) NSF to more fully utilize legislative authorization in ways beneficial to Nation.

B. Highlights of questioning

1. NSF predoctoral fellows originally full time on study and research: first allowed to teach in 1955; since academic year 1961–62, university allowed to pay up to $1,000 for teaching. At last count about one-third of fellowship holders from regular and cooperative graduate programs were teaching; believe proportion of traineeship grant holders would be comparable.

2. Maximum teaching allowance by institution originally set at $600; increased to $1,000 in 1964–65 fellowship year. Present figure believed appropriate.

3. Immigration of Ph. D.'s from north-central region to both coasts is result of (1) location of industrial R. & D. and (2) location of in-house Government R. & D. Believes immigration not as common now as formerly.

4. No objective yardstick exists to determine relative quality of various institutions at college educational levels below Ph. D.

5. Does not believe geographic distribution factors of less concern to NSF than formerly, or that NSF distribution of support is more concentrated at present.

6. On criticism that charts do not relate actual distribution of total population to other factors, a counter question was raised about NSF responsibility to strengthen education throughout the country, and use of its funds where some strength already exists. Thought the two objectives should be kept somewhat separate. Initiative and cooperation at grassroots needed.

7. Guideline for giving geographical preference not same for fellowships and research.

June 29, 1965

Witness: Dr. Donald F. Hornig, Director, Office of Science and Technology, Executive Office of the President.

A. *Highlights of statement*

1. Relationships between OST–NSF:

a. Noted difficulties inherent in original legislation that gave NSF overall policymaking and evaluation function, and changes made through reorganization since 1957 to focus policy formulation and central coordination in the Executive Office of the President.

b. Explanation of increased NSF budget—

Fifteen percent increase in total national program in basic research in universities figured on (1) plans of agencies for support of academic research, (2) projected growth of student enrollments, (3) increased costs of education and research. Because much support of basic research in universities comes from the NSF, nearly 50 percent proposed increase for this purpose.

Failure to obtain requested amount will result in declining support for university science students.

c. Present NSF participation in policymaking process consists of—

(1) Making policy recommendations and acting to enhance health of American science.

(2) Organizing and carrying out interagency studies and evaluations when requested by OST.

d. OST–NSF relationships:

(1) Relationships dependent on unique functions and capabilities of NSF:

(a) NSF as collector and analyzer of basic data on science resources and on nature of Federal R. & D. expenditures which OST uses for national science policies.

(b) NSF as executive agent or delegated agent of OST in exercising leadership on programs of broad importance, as for example, in developing interagency assessment of and reaction to NAS report on ground-based astronomy.

(c) NSF as a source of advice to OST on national science policies.

(d) NSF, supported by OST, has increasingly "taken into consideration" extent and character of other Federal agencies in support of academic research, as for example, intent of Foundation next year to use total Federal Government expenditures as base for institutional grant program.

(2) Relationships of NSF with other Federal R. & D. agencies:

(a) OST and PSAC review NSF programs as they do programs of other agencies.

(b) NSF is a full member of FCST and may provide staff for assistance on panels of FCST.

2. Major questions regarding future overall program of NSF:

a. Increase of NSF support of scientific activities directed at particular national goals.

b. Increased NSF attention to applied research presently not the responsibility of research of mission-oriented agencies; e.g., improvement of national systems for dissemination of scientific and technical information, and increased attention to education and academic research in engineering.

B. Highlights of questioning

1. One of the purposes of establishing OST was to provide more effective communication with Congress through appearances at Congressional hearings and through published reports; a report of FCST is now in process.

2. Method of operation of FCST is to coordinate agency activities in particular fields such that the exact location of a particular activity is subordinated to ready availability of end product.

3. Wooldridge report cited as example of evaluation of scientific research programs since this responsibility was transferred to it from NSF. Recommendations translated into action through (1) consultations, (2) submission of legislative programs, and (3) recommendations concerning agency budgets.

4. OST limited in evaluating role by size of staff. Sees committee method excellent for collecting information; but not to provide leadership.

5. OST summer study by a PSAC panel under Dr. Harvey Brooks will seek some rational guidelines for academic research and for its growth, choice among fields to support and coordination of efforts by many agencies. Will consider specifically (*a*) criteria for distribution of funds for research at universities to strengthen and increase number of first-rate institutions and to broaden the base of scientific research and education; (*b*) ways to broaden geographic distribution of support to universities; (*c*) balance between project support and increased institutional responsibility for larger program elements, and (*d*) role of postdoctoral students.

June 30, 1965

Witness: Dr. Frederick Seitz, President, National Academy of Sciences.

A. Highlights of statement

Discussed (1) importance of NSF to science in United States, (2) NSF–NAS relationships, and (3) NSF foreign activities.

1. National importance of NSF:

a. Creation of NSF recognized importance of basic science to the Nation.

b. In developing programs and budget, NSF administrators draw on advice from a large part of the scientific community. In dividing funds between NSF programs, congressional committees should seek advice of the "scientific community."

2. NSF–NAS relationships:

a. Scientists who proposed NSF were for most part closely associated with NAS.

b. President of NAS, Dr. Bronk, also chaired National Science Board for years.

c. Examples of NAS–NSF cooperation: (1) IGY; (2) Committee on Science and Public Policy—major support from NSF; (3) Project Mohole; (4) Office of Critical Tables; (5) Automatic language processing; (6) Scientific personnel—NAS evaluates NSF fellowship applications; (7) continuing study of special fields through special committees; as e.g., Committee on Polar Research, Committee on Atmospheric Sciences, etc.

3. NSF–NAS foreign activities:

a. Support of international scientific conferences and programs, such as IGY, international biological program, and International Indian Ocean Expedition.

b. Management of international scientific activity, through NSF–NAS support of U.S. national committees of international scientific unions, Scientific Committee on Antarctic Research, and Scientific Committee on Oceanic Research.

c. Scientific exchange activities with Academies of U.S.S.R. and of eastern European nations.

B. Highlights of questioning

1. No strong opinion whether NAS and NSF are too close to permit objectivity. During NSF's growth, close NAS ties were valuable. Working relations at present excellent. Sees no conflict of interest in concurrent NAS–NSF memberships "so long as issues discussed were general policy matters."

2. Would like to see scientific community consulted when adjustments are made in the NSF budget. Possible at this time by consulting the Academy, but Academy only one spokesman for the scientific community.

3. Against NSF involvement in any massive way in applied science activities.

4. Mission-oriented agencies must support basic research related to their missions.

5. Greatest concern is that pressure for support of very large programs will result in individual scientist not being adequately funded.

6. Considered 1966 NSF budget very well balanced.

7. NSF draws advice from the scientific community through its Science Board, various advisory panels, from PSAC, OST.

8. Believes private and State sources of basic research support are definitely growing in proportion to the Federal funding.

9. No simple solution to difficulties of small schools in attracting good researchers. Partial solution is for small school to establish relationships with bigger universities wherever possible, for use of facilities.

10. Would like to see a half-and-half allocation of funds between project grant support and institutional grant support.

Witness: Dr. Alan T. Waterman, former Director, National Science Foundation.

A. Highlights of statement

1. Breadth and flexibility of National Science Foundation Act of 1950 a tribute to Congress:

a. Misunderstandings concerning the act, which were later clarified:

(1) Initial decision that NSF should not support all of basic research. Decision confirmed by Executive Order 10521 of March 1954.

(2) Initial decision that NSF should not evaluate the the research programs of other Federal agencies. Evaluation functions in act interpreted to be evaluation of science programs, not agency programs. Agency programs should be evaluated at a higher level.

(3) Coordination of Federal agencies a responsibility of FCST and OST rather than NSF.

2. Suggestions concerning future of NSF:

a. NSF proportion of Federal support in basic research to academic institutions, presently less than 30 percent, should be markedly increased ["to at least 50 percent"].

b. NSF should lead overall consideration of basic research subject matter areas and should continue to develop the programs of its Office of Science Information Service.

c. Increased reliance on National Science Board.

d. Increased responsibility for support of education and training in science and engineering, in close cooperation with O. of E.

e. Continued cooperation with nongovermental scientific organizations.

f. Funds to provide (*a*) continuity of support, and (*b*) contingency funds.

g. Increased international cooperation.

3. Questions involving technology must be decided by society; they cannot be left to scientists and engineers alone.

B. Highlights of questioning

1. Motivations of mission-oriented agencies for engaging in basic research should be requested from agencies themselves. If matter becomes acute, would be a matter for study by OST.

2. No external guidelines exist concerning what basic research particular agencies may support. Individual agencies would have to be queried regarding internal guidelines.

3. Evaluation role of OST must be by categories of projects; panels to deal with matters within a category. Agencies must be made more aware of their review responsibilities. Suggested periodic overall reviews supplemented by closer agency communication and perhaps some delegation of authority from OST.

4. Science education should not in general be spread around among various agencies. Mission-oriented agencies should deal only in education at graduate level and only in specific areas in furtherance of mission. Activities should be coordinated with NSF.

5. Increased use of National Science Board suggested with respect to national policy for science and in educational institutions; could be useful to OST.

July 1, 1965

Witness: Dr. Dael Wolfle, Executive Director, American Association for the Advancement of Science.

A. Highlights of statement: The statistical functions of the NSF

1. Available NSF statistical information inadequate: wants more, in greater detail, more promptly:
2. Reasons for dissatisfaction with NSF statistical data:
   a. Questions can always outrun available information.
   b. Not feasible to collect all information that someone might want.
   c. Inherent limitations of future trends and projections.
   d. Inevitable delays in collection, processing, and publishing information.
3. NSF problems in data collection:
   a. As "focal agency" NSF has no "police power"; can only coordinate agency activities by persuasion and voluntary agreement.
   b. Low priority by NSF, Bureau of Budget, or by Congress.
4. Wolfle's recommendations:
   a. Assign a higher priority, and support, or stop complaining.
   b. Use better data-processing equipment.
   c. Collect manpower "flow" information in addition to information on current status.
   d. Establish a special agency to interpret, synthesize, criticize, and improve methodology of scientific manpower studies.

B. Highlights of questioning

1. If removed from data-gathering and reporting activities, proposed new agency could be established within NSF; function more important than organizational arrangement.
2. As stated in "Science" editorial, believes NSF role should remain in pure sciences, with applied science continuing to be the responsibility of mission-oriented agencies.
3. Shifts in fields or places of employment are related to (1) amount of training received in a field, (2) caliber of individuals involved. Fluctuations in budget support have not resulted in adversely affecting large numbers of persons.
4. While not familiar in detail with data-processing equipment of NSF, understand both NSF and O. of E. are studying their own needs and what newer and better equipment would aid them.
5. Does not believe interest in basic research has resulted in neglect of applied science or loss of leadership; problem rather one of balance or application: perhaps greater attention should be directed to gaps in applied activities, chiefly in nondefense, nonspace applications.

6. NSF stimulation of basic research has been beneficial overall despite resultant diversion from applied science.

7. NSF does not need additional legislative authority to devote more effort to manpower studies; principal need is allocation of more money to this activity; an increase in present allocation of 1½ percent of current budget to 2–4 percent would result in improved situation.

8. As Federal role in education increases, responsibility will have to be divided, either by (1) field of interest or discipline, or (2) between levels of educations. Suggestion in "Science" editorial referred to possibility of an organizational unit which would focus on maintenance of scholarship and education and research at the higher levels, and in all fields.

Witness: Dr. Chalmers W. Sherwin, Deputy Director, Defense Research and Engineering (Research and Technology), Department of Defense, appearing for Dr. Harold Brown, Director, Defense Research and Engineering, Department of Defense.

A. Highlights of prepared statement

1. Interaction between DOD and NSF—aspects of—
   a. At OST–FCST policy level.
   b. Interagency major program planning; for example—
      (1) Antarctic research program.
      (2) International Years of the Quiet Sun.
      (3) International Indian Ocean Expedition.
   c. Coordination on "small projects":
      (1) Problems—
         (a) Cannot be sure right agency is supporting right project.
         (b) Do not know of research proposals which never were accepted and sponsored.
   d. Mutual support of specific projects; for example—
      (1) Stratoscope II: NSF, DOD, NASA.
      (2) Joint radio-astronomy project at Cal-Tech.
   e. Exchange of information on composition of research programs:
      (1) Project ILSE.

B. Highlights of questioning

1. A centralized research agency which has coordinating authority on projects would result in a very cumbersome decision procedure. Preferable to provide for accurate reporting system.

2. DOD providing no direct support for science education. Supporting about $130 million to universities for research programs related to the educational process.

3. DOD giving no fellowships or individual aid.

4. Conclusions from project "Where Do Good Ideas Start?": Most of key advances came from designers and builders of systems equipment, locally financed.

5. No established guidelines in DOD for project acceptance or referral; believed unnecessary.

6. Organized procedure for evaluation by peers applies only to one-quarter of DOD support of research in universities; three-quarters of $400 million total support to universities for contract centers and applied research programs.

7. Public availability of materials from Project ILSE a possibility.

8. Determination of R portion of R. & D. contract very hard to estimate.

9. No DOD policy re geographical distribution of contracts.

10. No clearly established policy in Department of Defense on possibility of making geographic distribution a basis for selection when other aspects of contract selection not clearcut.

11. DOD has no mathematical analysis to predict long-range manpower needs; has studies, analyses, and plans, but they are without mathematical tools.

12. DOD uses NSF's scientific and engineering manpower information to the degree they are related; would like to see improvement in data; DOD would like followup information on persons it previously supported.

July 6, 1965

Witness: Dr. Glenn T. Seaborg, Chairman, Atomic Energy Commission.

A. Highlights of statement

1. NSF and mission-oriented agencies should continue vigorous support of basic research.

2. AEC–NSF relationships:

a. Means of coordinating scientific planning and programs:

(1) Physical research:

(a) Formal interagency committees established under FCST—

(i) Technical Committee for High Energy Physics.

(ii) Coordinating Committee for Materials Research and Development.

(b) Solid State Sciences Panel of NRC of NAS and liaison representatives to Division of Physical Sciences and Division of Chemistry and Chemical Technology of NAS–NRC.

(c) Informal interagency groups (about eight) concerned with program coordination.

(d) Exchanges of lists of proposals.

(e) Telephone contacts.

(2) Multiple agency support to individual scientists especially in chemistry and materials sciences. NSF has collected data from Federal agencies to reduce multiple support in certain fields of science.

(3) Basic nuclear engineering research considered neither basic nor applied research by AEC or NSF. Unsuccessful attempts made by AEC in fiscal years 1964 and 1965 to obtain funds for a separate category of "Basic nuclear engineering"; proposals still being handled within existing programs, as in the past. In role as "balance wheel" NSF could request increased funds for this activity.

(4) Biomedical research relationships vary according to field—e.g. systematic biology is responsibility of NSF; molecular biology, genetics, developmental biology and metabolic studies draw joint NSF–AEC support; in life sciences, AEC deals with NIH. Both AEC and NSF are represented on interagency committees.

b. Education and training activities:

(1) Major emphasis of AEC program is to provide equipment for training graduate students; training undergraduates is secondary; NSF provides equipment grants "for all

fields of science and solely for undergraduate teaching." NSF supplies equipment for general science programs while AEC concentrates on nuclear-science programs. Neither AEC nor NSF has sufficient funds to meet all educational needs.

(2) AEC policy regarding fellowships restricts granting to those whose stated intent is to prepare for careers in atomic energy.

(3) AEC recently instituted a traineeship program, similar to that of NSF which directs funds to specific institutions.

(4) Coordination through meetings of Federal fellowship administrators and re AEC–NSF specifically, through continuous informal exchange of data, plans and problems.

(5) AEC administers two types of faculty institute programs: (1) Short topical conferences for undergraduate and graduate faculty of engineering institutions, funded by AEC through ASEE, and (2) AEC–NSF faculty institutes and conferences for college and high school faculty in specialized topics.

(6) Support of nuclear reactors at universities. Since 1956 by informal agreement, NSF supports university research reactor construction, AEC support specialized training reactors. Neither agency providing level of support recommended by NAS–NRC panel reporting in October 1964.

c. Other more limited interactions AEC–NSF: providing data on R. & D. funding levels, getting NSF assistance on manpower surveys, in technical information area.

3. Future role of NSF:

a. NSF must support areas of research not now receiving adequate attention from mission-oriented agencies.

b. NSF must provide for additional educational opportunities for high school, undergraduate, graduate students and faculty in sciences.

c. Need additional funds—

(1) To support highest quality research.

(2) To support research at less well-known institutions.

(3) To expand science development grants and institutional base grants programs.

d. Additional efforts in curriculum development.

B. Highlights of questioning

1. AEC has had no jurisdictional disputes with NSF that have had to be referred to higher level for settling.

2. Informal day-to-day telephonic contact the most important coordinating device.

3. International scientific activities of AEC include—

a. Support of research abroad.

b. Exchange of information on peaceful uses of atomic energy.

c. Publication of nuclear science abstracts.

d. Support for attendance of scientists at international meetings.

4. Policy on support of research abroad—when it can be done better there than anywhere else.

5. AEC at present at a "sort of crossroads in our controlled fusion program;" panel under Professor Ellison of University of Chicago is expected to report by end of year; may then recommend different directions or possibly an expansion of program.

6. Problems of obtaining large amounts of energy from the fusion reaction not expected to be solved before end of century; more money might shorten time somewhat.

7. Shifting between fields of persons trained in nuclear physics no cause for concern.

8. AEC's research in universities quite widespread. Since isolation was a factor in location of national laboratories, result has been good spread also into remote areas.

9. Supported 15 percent increase per year to continue present level of academic support.

July 7, 1965

Witness: Dr. Hugh Dryden, Deputy Administrator, National Aeronautics and Space Administration, accompanied by Dr. Homer E. Newell, Associate Administrator.

A. Highlights of statement

1. Plurality of Federal research support has been accepted and endorsed by Federal Government and by academic community. Problem is how to coordinate the total Federal research activity in the national interest.

2. NASA–NSF interrelationships—aspects of—

a. Support of basic research.

b. Graduate training.

Coordinating through (1) meetings with heads of agencies and Federal fellowship administrators—an ad hoc interagency group; (2) Federal Interagency Committee on Education; and (3) daily contacts between staff.

3. Suggestions for future role of NSF:

a. NSF must take lead in developing of a broad base of scientific activity in all parts of the Nation, while mission-oriented agencies must continue to give prime consideration to competence.

b. NSF might extend its activity to research and training at undergraduate level, at present receiving too little Federal attention.

B. Highlights of questioning

1. Recommendation for increased education support to undergraduate students not exclusively directed to NSF; NASA has also considered; institutional aid suggested rather than more direct aid to individual undergraduates.

2. Mission-oriented agencies must give prime consideration to competence when selecting proposals for applied R. & H.; not so critical for basic research.

3. NASA sponsors few social science projects; agrees that NSF's responsibility should include social sciences and engineering.

4. NASA and NSF coordination: Information on proposals and actions exchanged; periodic lists assembled; frequent telephone and personal contacts. NASA also cooperates with SIE. OST coordination noted.

5. NASA program managers are responsible for getting their jobs done. They solicit and receive proposals for R. & D. and decide whether work should be obtained from colleges and universities or industry, or from NASA centers. NASA also has a more general program for university research which receives unsolicited proposals.

6. Decision for NASA to support production of 1,000 Ph. D.'s annually was an executive branch decision extending from PSAC: part of a concerted agencywide effort to increase number of Ph. D.'s by 4,000 a year; doubts NASA would continue at same rate indefinitely.

Witness: Dr. Don K. Price, Dean, Graduate School of Public Administration, Harvard University.

A. Highlights of statement

1. Price considered role of NSF, in relation to other Federal agencies including—

   a. Executive branch development of its science policies, and

   b. Relation of applied and basic research throughout the Government.

2. NSF is a "most successful political invention."

3. Main issues debated during establishment of NSF were relation of science to political authority and relation of basic science to applied science. Noted that the former was the more fundamental problem, but the latter has caused more difficulty.

4. Science and political authority:

   a. Broader and more practical support of science by Government raised fears of science being supported for its social utility and being directed by political authority—not advocated by Bush report which stressed basic research in independent institutions. Fears proven groundless. Science supported in United States for its utility since Republic began. Fear of inept political authority overcome by use of advisory panels for project review—"no subsidization without representation" as an established political principle in administration of science programs. National Science Board and National Science Foundation divisional committees, originally constituting a system of checks and balances, have evolved into normal administrative machinery.

   b. Creation of OST and transfer of NSF coordinating functions by Reorganization Plan No. 2 has given NSF greater, not less, range of potential policy influence. Policy a multi-agency and branch concern. NSF's range of potential influence is greater because NSF can be persuasive in its information and advice to OST.

5. Basic and applied science—complexity of problems unforeseen in 1950. Desirable lines for future policy:

   a. Avoid segregation of science into a single department. Science and policy are part of mission of every Federal agency.

   b. Do not confine agency activities to applied research alone. Basic research can make an agency's applied research program more productive; pluralism in sources of support for basic research is fundamental protection for scientific freedom.

   c. NSF should concentrate on its original purposes—support of basic research and science education. No danger that universities will seriously distort their programs to get grants. NSF responsibility for applied research should be exception, not rule.

   d. Closer tie in future between NSF, NIH, and Office of Education; possibility of single department seen.

B. Highlights of questioning

1. Fundamental organizational problems reason why NSF could not coordinate science activities of other operating departments:

   a. An agency headed by part-time board could not exercise continuous coordinating responsibility over other operating departments.

   b. Agency organized to deal with basic research would not understand major operational programs of Government.

   c. Isolation from President's political leadership made it impossible for NSF to exercise same kind of coordinating authority that Executive Office could.

2. Staff for NSB: "If the staff is not serving the Board's purpose, I think the Director ought to be asked by the Board to get a different staff." Suggested strengthening NSF staff to serve Board more adequately; also providing additional staff to work on policy content of problems and on general problems of science.

3. Working relationships between NSF and other agencies involved in research and education is "basically on sound lines."

4. Saw no alternative to NSF's responsibility for weather modification or Project Mohole.

5. Supported NSF decision not to assume responsibility for coordinating oceanography.

6. Establishing an environmental science department makes most sense of all proposals; does not know whether or not Commerce's role in this area should be strengthened.

7. Saw an eventual closer relationship between O. of E. and basic research programs of NSF and NIH—perhaps a loose confederation of agencies.

8. Spoke of open recognition of Federal support of higher education and how to implement policy to spread funds. Advocated continued project grants by NSF at not less than half present budget; agreed some shift may be necessary to make more institutional grants.

9. Concerning overlapping membership between National Science Board, NAS committees, PSAC, etc.:

   a. Saw no conflict of interest, and

   b. Saw no solution to problems caused by same first-rate persons serving in multiple capacities; did not believe this serious for NSB.

July 8, 1965

Witness: Dr. Alvin M. Weinberg, Director, Oak Ridge National Laboratory.

A. Highlights of statement: Future role of National Science Foundation

1. Summarized reasons in recent NAS report favoring greatly expanded NSF, particularly as a source of support of academic research in physical sciences.

2. Mission-oriented support of basic research is necessary (*a*) to maintain necessary environment for doing applied task, (*b*) to make new discoveries, (*c*) to solve problems arising in course of applied task.

3. Tolerant attitude of last decade and past level of academic basic research support cannot be maintained in mission-oriented agencies if support for applied missions does not continue to grow correspondingly. Spending for defense, atomic energy, and space already levelled off; therefore basic research which AEC, DOD, and NASA have been funding cannot continue to increase to levels necessary, with result that university physical and engineering sciences may be inadequately supported.

4. No corresponding problem regarding biomedical sciences. The need is recognized and NIH will continue to expand role as an NSF for basic biological sciences.

5. Three major sources for increased support of physical sciences suggested: (*a*) Expansion of commitment of NIH to physical sciences, e.g., in biochemistry, biophysics; (*b*) new agencies set up for problems such as urban transportation, air pollution, etc., should support some basic physical science, and, most important, (*c*) increase support by NSF.

6. Annual 15 percent increase of NSF budget for university research recommended; by 1970, NSF budget should exceed $1 billion. NIH and NSF foreseen as principal basic scientific agencies—NIH for biological sciences and NSF for physical sciences, especially in universities, and also other aspects of science not funded sufficiently by mission-oriented agencies. Eventually much more than half of university physical science to be supported by NSF (75 or 80 percent).

7. Annual NSF appropriation review seen as future forum for debate on basic research.

8. Government-higher education relationships will have to be debated as universities and Government laboratories compete for basic research funds.

B. Highlights of questioning

1. In light of stabilization of mission-oriented agencies budgets, helpful to have short-term agency guidelines for basic research support.
2. Figure of $1 billion for NSF by 1970 only an estimate—for NSF to become a "very, very major element" may need $1.5 billion or more. Fifteen percent rate of increase for NSF too low.
3. Relative support between physical and biological sciences should be closer to 1-to-1 basis rather than 3-to-1 or 4-to-1 ratio at present. Increased support for biological sciences emphasized.
4. Future new agencies likely to deal with new public problems having a systems character or social science character rather than physical science orientation.
5. Social sciences problems exceed in importance those of biological sciences but do not see where large sums of money can be spent in social sciences. Need a point of departure.
6. Competition between universities and in-house government laboratories a source of increasing difficulty—uncertain whether a serious problem.
7. SIE doing some things very well but not really serving as an operating service as does the U.S.S.R. overall science information service. Fault probably lies in inability of OSIS of NSF to coordinate science information for all Government agencies. COSATI doing good job with some of functions originally assigned to OSIS.
8. Putting NIH and NSF in one agency would dilute mission orientation of NIH with serious consequences.
9. Biological science support should continue by NSF but not at levels of physical sciences.
10. Study of civil defense problems at Oak Ridge a particular case arising out of interest of Professor Wigner, an Oak Ridge alumnus.
11. Not familiar enough with NSF to say whether present organization adequate to handle recommended growth. On present knowledge, believe overall structure could serve a $2 billion agency as well as one of present level.

Witness: Dr. Charles Kimball, President, Midwest Research Institute, Kansas City, Mo.

A. Highlights of statement

1. Not-for-profit institutes—
   a. Principally concerned with application of science and technology to economic growth and social change. Date back to founding of Mellon Institute in 1913; total employment 1964 was 11,000; research volume $150 million; influence very much out of proportion to expenditures.
   b. Effectiveness due to broad approach, objectivity, skill in blending scientific interest with commercial, economic, or mission objectives, and ability to do high-quality research within competitive costs and time limitations.
   c. No appreciable contractual or grants from NSF to not-for-profit institutes, because of NSF concern with basic academic research and because NSF has not regarded applied research as its responsibility.

2. Future role of NSF in technology:

a. Called for university programs to include training of "appliers of science" who can identify and solve problems relating to technology and economic growth.

b. Suggested special summer institutes as initial effort; later incorporate training programs in graduate business schools or engineering schools.

3. Other issues identified:

a. Need for improved technology in certain industries, particularly textiles, construction, metalworking.

b. Geographic distribution of R. & D. and influence of NSF on.

B. Highlights of questioning

1. NSF could be more active in transfer of knowledge by supporting training of people with this ability, and by assisting in exposing basic reseachers to applied research problems and vice versa.

2. Federal funding to assist emerging centers of competence could produce better geographic distribution of R. & D. activity. No criteria for selection to suggest—would hope they would be "other than political."

3. Research institutes might assist NSF in training "appliers of science."

4. Not-for-profit institutes have closer relationship with Commerce than with NSF.

5. No lack of clarity in split between functions of NSF and Department of Commerce.

6. It is the small corporation that needs assistance on technology utilization and transfer; large corporations have own resources.

7. Major task in attracting scientists was to sell idea that Midwest was neither intellectually nor geographically arid.

July 13, 1965

Witness: Dr. I. I. Rabi, Professor, Columbia University.

A. Highlights of statement

1. Covered applications of science to strengthen international relations of United States and open new avenues of communications.
2. Examples of importance of science to international relations:
   a. First Conference of Peaceful Uses of Atomic Energy in Geneva in 1955 where United States and Soviet scientists met was beginning of lessening of tensions between United States and U.S.S.R. Contacts there led to ratification of Test Ban Treaty.
   b. United States proposed formation of high energy physics laboratory by European nations; resulted in CERN.
   c. Scholarship program under NATO Science Committee.
3. Military departments, NIH, private foundations, and National Academy of Sciences support programs abroad or maintain relations with scientists from other countries.
4. No central office or organization exists in United States to maintain continuous international scientific communications.
5. Suggest NSF in cooperation with Division of Science Affairs in State Department expand international program and influence.

B. Highlights of questioning

1. Although Division of Science Affairs in State Department is primarily concerned with international participation in science, termed performance "consistently disappointing" due to lack of use by Secretary of State.
2. Agreed that scientific organization in State Department may be accepted with time and experience.
3. Believes NSF could do a great deal to improve the image abroad of the United States by publicizing the American educational system. As operating agency, can utilize fellowships, cooperative projects, visits.
4. With reference to good job the military agencies have done abroad through grants program, believe if NSF had the quality of personnel to do the job, "it would be easier to do a better job" because of traditional antimilitary sentiment of European scientists.
5. Supports NSF taking over international science needs which must be met as military budgets are stabilized or reduced.
6. On possibility of international cooperation with respect to the landing vehicle for Voyager project, thought it would be "very difficult." "* * * I would be afraid of it, particularly if it were international enough to involve the Soviet bloc * * *" due to differences such as industrial systems, writing blueprints, etc.

7. On evolution of science in China and India, believes Chinese could become the leading scientific nation. "Vital" that a top-level scientific team visit China.

8. Would like to see NSF have research support role comparable to DOD; DOD and AEC should not withdraw support.

9. Favored empirical approach on proportion of research NSF should support. Would increase support and evaluate situation year by year.

10. NSF should enter field of high energy physics "in a very big way"—to support building of a facility of energy higher than 500 million volts and to support additional facilities in lower energies.

11. Does not know whether research on brain and nervous system are receiving adequate attention.

12. On balance between social sciences and physical sciences, believes support is and should be forthcoming in any area which shows progress.

13. Pointed out social sciences get a great deal of support from private foundations; also that equipment needs in physical sciences so expensive, numbers of people supported may not be very big.

14. Science is ultimate challenge for the present and for the future. Thought competition between nations as symbolized by Sputnik had been good for United States in spurring us to a better effort.

15. Did not agree that the bigger problem was the needs of underdeveloped countries rather than spectaculars in the physical sciences. Thought advances in physical sciences would lead to devices which can be applied to other problems.

16. Saw NSF moving gradually into high and low energy physics, perhaps cooperating with AEC and gradually taking over.

17. Spoke feelingly on disadvantages to individual careers of taking positions in Foreign Service or Government—a very serious matter.

Witness: Hon. Francis Keppel, Commissioner of Education.

A. Highlights of statement

1. Office of Education-NSF relationships range from statutory requirements to informal contacts.

2. Informal contacts include staff consultations, informal interchange on advisory committees, and telephone.

3. O. and E. and NSF routinely refer proposals to each other in areas clearly the responsibility of one or other agency.

4. In new curriculum, teacher training institutes and fellowship programs, O. of E. has benefited from NSF experience.

5. Four major areas of O. of E./NSF mutual responsibility:

a. Construction of graduate facilities, under Higher Education Facilities Act of 1963—

(1) Program aimed to develop new centers of excellence in graduate studies.

(2) Managed by advisory committee of educators and representatives from NSF and PSAC.

(3) O. of E. support for facilities for teaching and research complementary to NSF support to research facilities.

(4) Ad hoc committee of O. of E., NIH, NSF, and NASA established February 1965 to coordinate various graduate facilities programs.

(5) Major differences in O. of E. and NSF programs besides NSF research emphasis:

(a) NSF can make matching grants up to 50–50 basis; O. of E. grants are limited to one-third. Administration seeking liberalization of current matching requirements. Amendment sought for discretionary authority rather than a flat amount.

(b) Seventy percent of O. of E. program nonscience.

b. Improvement of qualifications of elementary and secondary school teachers:

(1) Institutes program supplements training in science and mathematics. O. of E. institute program originally for modern foreign languages; in 1963 extended to teachers of English to non-English-speaking students, and in 1964 to above programs and seven new types: teachers of history, geography, reading, English, disadvantaged youth, school library personnel, and educational media specialists.

(2) Intent and implementation of O. of E. institutes similar to those of NSF.

(3) Possible overlap in support for institutes in geography.

c. O. of E. graduate fellowship programs—$2,500 each to institution and to student:

(1) Congressional intent to provide fellowship support to new or expanded doctoral programs. Tried to spread available assistance as equitably as possible.

(2) Program fundamentally altered by Congress in 1964:

(a) Number of fellowships awarded raised from 1,500 in 1964–65 to 3,000 in 1965–66, 6,000 in 1966–67 to 7,500.

(b) Awards vacated made available to its institution for reallocation.

(c) Half of fellowships for fiscal year 1965 and two-thirds in fiscal year 1966 released for allocation to doctoral programs which had capacity to enroll additional students with existing staff and facilities.

(3) Policy in awarding Ph. D. fellowships changed upon recommendations of a statutory advisory committee and a group of university advisers to provide for allocation in concentrated blocks to institutions exhibiting promise of excellence.

(4) Criteria for determination of promise of excellence (*a*) judgment of peers, (*b*) proposal reviewed as institutional whole by overall advisory committee.

(5) Distribution of program, 60 percent in humanities, education, and social sciences, 40 percent in biological, physical, and engineering sciences.

d. Other legislation authorizing O. of E. to conduct research in education—

(1) Handicapped children.

(2) Modern foreign languages.

(3) New educational media.

(4) Adult and vocational education.

(5) Cooperative research program—most extensive and one with which NSF is most involved.

6. Criteria for review: significance research design competence of staff and facilities, and economic proficiency of proposed project.

7. Curriculum improvement program—may concern whole curriculum, or a particular course or subject at any level. O. of E. tries to identify and stimulate projects to fill gaps created by specialized courses or curriculum or provide alternatives to existing curriculum improvement effort.

a. O. of E. and NSF agree on necessity to have available several types of new curriculum which local school authorities may use as a guide.

b. Wide variation across country in State control of curriculum; State legislative actions usually limited to a particular subject.

c. Coordination between NSF and O. of E. on curriculum improvement by (*a*) appointment of NSF staff member to O. of E. curriculum improvement review panel, (*b*) joint site visits by two agencies, and (*c*) joint review and funding of proposals relating to both.

8. NSF and O. of E. relationships which need further consideration—

a. Continued cooperation in course content improvement projects, to insure curriculum choice and experimentation at local level.

b. Institute and curriculum improvement programs of both agencies will need to be more intimately related.

B. Highlights of questioning

1. Spoke of the applicability of new techniques under educational media program. Was asked to supply information about research in program instruction, educational TV, and satellite communication.

2. O. of E. fellowship support of 60 percent to humanities and social sciences intended to reflect balance between numbers of college teachers in humanities and social sciences on one hand and sciences on other. Since O. of E. program is intended to increase number of college teachers, a statement of intent of applicants is requested—it is not an indenture.

3. Do not believe, putting all various agencies and fellowship programs together, that the need and supply for teachers in both social sciences and physical sciences is being balanced.

4. Supported present 60–40 balance for distribution of additional funds.

5. Agreed to obtain for record amount of total support, for graduate education and institutions which comes from all Federal agencies. Amount of State contribution also requested. Undergraduate totals as well as data on elementary and secondary levels also mentioned.

6. Did not say whether percentage of NSF fellowship support should be increased. With respect to O. of E., needs more money for libraries. Did not think it wise to greatly increase number of Ph. D. fellows in title IV of NDEA.

7. Opposed setting up a Department of Education encompassing Federal education functions:

a. Various agencies have used university resources for their goals; should not be prevented from direct relations.

b. To channel all activity through a central office would "probably slow up the paperwork."

July 14, 1965

Witness: Dr. Harvey Brooks, Dean, Division of Engineering and Applied Physics, Harvard University.

A. Highlights of statement

Statement directed to (1) criteria for support of basic research; (2) NSF role as viewed by individual investigator; (3) NSF statistics, and (4) role of NSF in applied sciences.

1. Criteria for support of basic research.

a. For views on subject, referred to paper in Academy report, "Basic Research and National Goals."

b. Proposed three classifications of basic research—

(1) Establishment basic research—performed in Government laboratory or Federal contract research centers.

2. Programmatic basic research—"big science." Two types: (*a*) Centered around complex and expensive equipment or (*b*) centered around cooperative attack on a problem by scientists from different disciplines.

(3) Academic research—both basic and applied research in connection with training of graduate students or other research personnel. Two types: (*a*) Mission-oriented academic research and (*b*) discipline-oriented academic research. All qualified students should be supported, at levels set by national policy. Fields to be supported should in general be determined by scientists, in contrast to programmatic research where applied needs take precedence. Need to be only indirectly oriented toward national needs.

c. Funding of establishment and programmatic research are more explicitly political than of academic research, although the total of academic research is also political.

d. NSF current funding of academic research should rise from approximate level of 13 percent of the total to 25–35 percent, with not more than 80 percent in any one field to come from NSF, to preserve competition. Percentage of NSF support suggested established from a number of qualitative considerations—a "visceral feeling"—three times the present 13 percent and still under 50 percent.

e. While NSF may have been too conservative in past in developing new fields or transferring funds, would not like to see it err in other direction.

f. "Proposal pressure" still best measure of relative needs and should continue as primary although not sole basis of judgment in allocation of funds within basic research support grants.

g. Science development program will lose its purpose if basic research support grants are not increased to take care of new capabilities which program is expected to create.

h. Non-Federal sources of support for university basic research and "little science" have kept pace with Federal funding. Proposition of Federal funding has increased for university research, due to increases in applied research. Federal proportion of funding for industrial R. & D. has increased from about 40 percent to 60 percent in last 10 years. Expect to find out more about State funds from the PSAC summer study.

i. Criteria for establishment research should be "primarily a decision of the local management" influenced by (1) Agency dependence on advances in basic science, (2) relevance of basic research to long-range goals of agency, (3) integration of basic research with the applied research, (4) past performance of agency in its mission, and (5) competence of personnel for basic research.

j. Criteria for establishing new programmatic research institutions: (1) Availability of scientists who will support program, (2) inability to meet need through existing facilities, (3) insufficient funding, (4) expected novel and intrinsic intellectual significance of scientific results, (5) contribution to other areas of basic science, (6) potential contributions to future technology, and (7) contributions to education and training of future scientists and technologists.

k. Criteria for academic research: (1) Promise of significant scientific results from project, (2) novelty, originality, and uniqueness of work proposed; (3) degree to which results likely to influence other research, (4) educational value of work, and (5) possible relevance to future applications.

2. NSF role as viewed by individual investigator:

a. Academic research should be NSF's major concern.

b. NSF should support programmatic research only to provide opportunities to university scientific community not otherwise available.

c. Project support should continue for academic research with a better balance between it and institutional grants.

d. Project support also broadens perspective of panel members in own fields, makes them aware of projects elsewhere and to avoid undesirable duplication or overlap, and recognizes outstanding performance of investigators wherever they are, especially in smaller or lesser known institutions.

3. NSF statistics:

a. NSF leads world in collection of statistics.

b. Suggested areas of improvement:

(1) More effective use of sampling.

(2) Closer ties between planning and statistical groups with program officers in NSF.

c. Needs of OST and of Congress will strengthen data collection program by giving it focus and policy relevance.

4. NSF and applied science: NSF should support applied science only where it would make important contributions to advanced training of technologists.

B. Highlights of questioning

1. Division of support between NSF and mission-oriented agencies varies with dependence of the mission on basic research. Suggest 60- or 70-percent support by mission-oriented agencies for solid state physics while in astronomy, NSF share might be 70 percent.

2. Individual excellence should receive higher priority in academic research than in establishment research.

3. Very little institutional basic research today done without outside funds from private or Federal sources. University and Federal funding so merged, difficult to separate.

4. All academic research is selected in some fashion. "Even that which is selected by the individual is selected in a sense." "* * * the idea that the university faculty member is completely free to do anything that he wants is inversely proportional to the cheapness of what he wants to do." A certain amount of flexibility is provided by institutional base grants.

5. Academic research criteria are applied "somewhat intuitively, perhaps not explicitly" by NSF panels and university deans and department chairmen.

6. Did not know whether NSF methodology in statistics is up to date. Has heard comments that methodology is good.

6. Did not know whether statistical problems could be met by funding. Believed more funds necessary in next 5 to 10 years but uncertain how funds would be used best. PSAC summer study may provide some additional information.

Witness: Dr. James A. Shannon, Director, National Institutes of Health.

A. Highlights of statement

1. NSF position central in structure of Federal science organization. Any changes in concept or functions will affect ability of mission-oriented agencies to discharge their roles and, in fact, will make necessary modifications in the total Federal science support role.

2. Reviewed present NIH activities showing interrelationships with NSF programs and responsibilities, described joint NSF–NIH effort, and discussed present and future role of NSF in science and education.

3. Present NIH activities and interrelationships with NSF:

a. Primary NIH mission is understanding of behavior and biological requirements for health and for an understanding of disease. NIH has major role in support of research in institutions of higher education and an indirect through major role in graduate education, through principle that effective research support implies an obligation to assure manpower resources for continued future growth.

b. NIH research arm of PHS. Institute concept stems from creation of National Cancer Institute in 1937; broad authority for extramural research project grant support made available in

Public Health Service Act of 1944. By time of creation of NSF in 1950, seven of nine present research institutes had been established, and Federal Government was heavily involved in support of academic sciences through mission-oriented agencies.

c. Nature and extent of NIH–NSF relationships: Collaboration on (1) specific scientific studies; (2) terms and conditions of support for research, training fellowships, and facilities programs; (3) use of peer group review system for academic research; and (4) on coordinating activities and programs focusing on same institutions.

4. Examples of NSF–NIH cooperation mentioned at top, intermediate, and working levels. Informal and formal relationships noted. Purposeful overlap in programs to avoid inadvertent gaps. NIH–NSF have jointly financed studies re scientific manpower, graduate education, and university activities of common interest.

5. Future role of NSF:

a. Continuation of present support patterns with flexibility.

b. NSF should fill gaps and deficiencies in science structure left by mission-oriented agencies.

c. Looks to NSF to support science as a national resource and to carry out "balance wheel" role.

d. Aspects of NSF, NIH, and O. of E. relationships in Federal support for academic sciences:

(1) Although O. of E. dominant in training and construction of educational facilities, role in support of science is minor.

(2) In face of declining DOD expenditure, NIH and NSF support is critical for university research.

(3) NIH future growth seen in—

(a) Basic science research relating to major diseases.

(b) Bringing physical, behavioral, and mathematical sciences in closer relationship with biomedical sciences.

(4) NSF increasingly will be involved in direction and management of large-scale science projects; this is sound only so long as increasing resources to growth of academic research are available. Of concern is the constantly rising cost of large-scale science projects.

e. Contradictions in NSF budget:

(1) Increased support for science development program concurrently with cutbacks in NSF project support.

(2) Inadequate attention to long-range consequences of certain funding decisions.

f. Optimum utilization of intellectual resources will determine position of United States in future.

B. Highlights of questioning

1. NIH/NSF show surprisingly little overlap. Only a small portion of total proposals could go to either. All large program expenditures receive at least informal joint consideration. Fifty percent of NIH funds go to professional schools related to health professions; 25 percent to universities, in areas of biophysics, biology, veterinary schools, etc. NSF clientele predominantly nonmedical in universities.

2. NIH only agency supporting behavioral sciences until NSF established. Has continued through Mental Health Institute and recent Institute of Child Health and Human Development.

3. NIH has no category of support for social sciences. However, about 10 percent of total resources being spent in psychology, cultural anthropology, etc., which are areas of social sciences relevant to health.

4. Establishment of environmental sciences group "highly desirable."

5. Both NIH and NSF support psychologists.

July 15, 1965

Witness: Dr. Augustus B. Kinzel, President, National Academy of Engineering.

A. Highlights of statement

Statement on Federal support of engineering and the need for increased NSF support.

1. Need for Federal support of engineering

a. Application of science through engineering stimulates the economy.

b. Although engineering primarily is responsibility of industry, Government support essential when—

(1) Objective is for a governmental function, as defense.

(2) Subject is so broad that one organization cannot finance.

(3) Costs of studies on special use requirements for materials cannot be justified by industry.

(4) Basic engineering advances are needed.

2. Need for increased NSF support

a. Proportion of NSF engineering support unchanged from fiscal year 1964 to fiscal year 1966 (11.2 percent versus 11.8 percent) despite announced intention of increased emphasis.

b. Government support of engineering sciences was 7.4 percent of total Federal basic research for fiscal year 1966; for fiscal year 1965 it was 6.6 percent.

c. Noted lack of engineers on Foundation staff.

d. "Woeful lack" of NSF engineering fellowships at graduate level.

e. Suggested budget increase and executive action to increase engineering research.

B. Highlights of questioning

1. "Executive action" refers to formal or informal NSF directives concerning increased engineering support.

2. While formation of National Academy of Engineering will increase emphasis on engineering, this will take time.

3. Does not agree that United States has lost world lead in applied science.

4. Emphasis on basic research may have been one of factors in lack of interest of NSF in engineering.

5. Believes United States still preeminent in engineering. Quality, not number, of engineers is the problem.

6. Agrees NSF's role in mission-oriented basic engineering should be only filling gaps. NSF has important role in fundamental engineering and systems engineering.

7. Agreed with Dr. Brooks concerning applied science education role of NSF in advanced technological training and retraining. Training should also extend to fundamental engineering.

8. While industrial scientists and engineers are fairly well represented on panels of NSF, representation could be better.

9. Mission agencies have responsibilities to retain technologists and engineers for specific functions; updating technological knowledge should be a function of NSF.

10. Difficulties of training engineers in design might be partially met by specific designation of certain number of fellowships for this purpose.

11. Concerning an interim program for engineers similar to that for doctors, referred to existing cooperative education programs.

12. NAE hopes to advise NSF as does NAS.

13. NAE would accept responsibility for applied research; task of actually doing the research would be referred to the National Research Council.

14. Believes more engineering representation helpful to NSB.

(NOTE.—Statement by Dr. Leland Haworth in testimony of August 19, 1965, presents certain data which is at variance with Dr. Kinzel's testimony.)

Witness: Dr. J. Herbert Hollomon, Assistant Secretary of Commerce for Science and Technology.

A. Highlights of statement

1. Commerce-NSF relationships:

a. Formal arrangements:

(1) Through national research programs, e.g. NBS, Weather Bureau, and USCGS participation in IGY, Antarctic research program, International Indian Ocean Expedition, United States-Japan cooperative science program, and International Year of the Quiet Sun.

(2) Through NSF initial funding of new programs in Commerce, e.g., National Standards Reference Data System and Clearinghouse for Federal Scientific and Technical Information.

b. Wide range of casual contacts between Commerce and NSF analytical and funding groups.

2. Questioned NSF role for applied science or operating large projects, except in fields of education and science information:

a. Weather modification: (1) Believed assignment of responsibility to NSF for information gathering on weather modification has resulted in loss of initiative by other agencies to develop programs. Matters now being studied by Commission of National Science Board and Interdepartmental Committee for Atmospheric Sciences.

b. Atmospheric research: (1) Questioned support of National Center for Atmospheric Research wholly by NSF. NCAR has tended to become a "creation of NSF without either educational or mission responsibility."

c. Meteorology: (1) Large-scale program of worldwide weather observations will be necessary to determine whether improved

predictions are possible. Should this be responsibility of NSF or of agencies "that will have to put the results to work."

3. NSF's long-term objectives should be focused on building the "institutions of science," rather than on solution of specific scientific questions.

a. NSF view of science, as an institution, too restrictive:

(1) Should have greater concern with science of people and their behavior, with institutions people create, and with interaction of people with environment and society.

(2) Should focus national efforts on problems such as transportation, communications, shelter, urban society, education, industrial production, and economy.

b. Educational institution-building:

(1) Need broader base of support for greater variety of scientific subjects—urged development of many centers of excellence.

(2) Support for institutional programs should be expanded and strengthened.

B. Highlights of questioning

1. Believed NCAR should be supported by other interested Government agencies in addition to NSF.
2. Weather research should be supported by all agencies who have a "real interest" in it.
3. Did not say who should have scientific responsibility for world-wide meteorological study. Suggested this is an appropriate question for "this committee" to examine: Should NSF (1) fund and/or (2) operate experiment.
4. Agreed that emotional response to atom bomb responsible for emphasis on physical science.
5. Agreed that 19th century interest in science was motivated by need for food and agricultural research.
6. Urged consideration of who should have predominant role in contemporary science problems closely tied to the economy, e.g., industrial production, transportation, communication, urban development, house and building construction.
7. Agreed consideration should be given to need for some other agency (suggested by Mr. Brown) to focus on problems dealing with the relationships between science, the people, and the economy.
8. Suggested three steps to advance a new program: (1) establish institutions throughout country to carry on program, (2) provide for support for research, and (3) provide means of connecting research with the recipients. State Technical Service Act would provide means to implement step (3).
9. Did not give opinion whether NCAR should have been included in the environmental sciences group. Said present situation "not necessarily" criticizable.
10. Deferred opinion whether or not NSF should have responsibility for Mohole. Did not know whether environmental science grouping would be a "fairly logical place" for Mohole.
11. Did not know of consideration to possibility of leasing Federal facilities for industrial research. Mentioned limited research associate program where industrial associates can utilize facilities of NBS. Will try to furnish information on industrial firms or nonprofit organizations being allowed to use Government facilities.

July 20, 1965

Witness: Dr. Herman Pollack, Acting Director, International Scientific and Technological Affairs, Department of State.

A. Highlights of statement

Discussed (1) interaction of science with foreign affairs; (2) how State Department deals with science; and (3) NSF involvement in international activities.

1. Science and foreign affairs:

a. Successful foreign relations requires utilization of all resources, including science. Hesitance to so use science caused by fear of identifying science with politics thereby destroying its integrity.

b. If interests of good international science and good foreign policy are contradictory, neither scientific nor political goal will be attained.

c. Suggested authority comparable to that in Public Law 86–610, July 12, 1960, for international cooperation in health research be obtained for international status of science in general on behalf of President or an agency such as NSF.

2. NSF's role in international participation: NSF might supply "seed money" for international activity of agencies until these can be continued with other funds.

B. Highlights of questioning

1. State Department has no authority to transfer funds to NSF; does transfer $25,000 annually to National Academy of Sciences for advice on the Department's international scientific programs.

2. NSF and State cooperate on scope and size of Antarctic program; NSF acts at State's request on United States-Japan cooperative science program. No nation-by-nation review made to identify needs or roles nor is there an organization to do so.

3. Only two specific instances of employment of Public Law 86–610 recalled. Under consideration with respect to medical science in Japan.

4. Will supply record of funds in research grants to foreign investigators justified by their expected contribution to U.S. efforts—for NSF, military, and other agencies. Admitted State Department inability to provide guidance to NSF.

5. Have predictions for Western Europe of future position in "economic and political spectrum" by analyzing support for science education and industrial research; do not have for China or U.S.S.R.

6. Could not say whether China might become top scientific nation in world.

7. Guidelines for behavior of delegates at international conferences vary according to the organization. State Department controls statements of policy of Government agencies sending delegation or representatives to international meetings.

8. Information on State Department funds for scientific cultural exchange will be supplied.

9. Exchange program with Soviet Union and bloc countries carried out by National Academy of Sciences with NSF funds and State Department advice. Will find out if funding adequate.

10. Teachers exchange program carried on by Bureau of Cultural Affairs. Both O. of E. and State Department fund teachers exchange programs. To furnish a summary.

11. Science attachés maintained in 16 countries. Present funding adequate in all but three posts.

Witness: Dr. Pendleton Herring, President, Social Science Research Council.

A. Highlights of statement

1. Emphasized social sciences as great American development. Touched on (*a*) social science program in NSF, (*b*) broader view of Social Science Research Council, (*c*) more stable support for social sciences, (*d*) more effective representation of the social sciences, and (*e*) significance of social sciences for future—their national and international contributions.

a. Social science program in NSF:

(1) Received token support until Sputnik.

(2) 1960 background paper on creation of NSF Division of Social Sciences seen as move to attract support proposals from leading social scientists.

(3) Grants in social sciences have increased from $2 million plus for 1961 to over $10 million in 1965. While rate of increase has been steep, NSF support of social science research is very modest.

b. Broader view of social sciences: (1) Federal Government a great consumer of social science. Support has been modest—on occasion too much supplied too fast, and cut off too soon. Mission-oriented agencies support of social sciences only a byproduct of their activities.

c. Increasing stability of support:

(1) Problem is not the absolute amount of support but the conditions under which given—continuity and spirit.

(2) Hopes for direct and open support of social sciences.

(3) Social Science Research Council took lead in bringing together university personnel and private foundations to build up centers for social sciences.

(4) Social science research can produce results relatively quickly, given a sense of purpose, and reasonable financial support and national need.

d. More effective representation of social sciences:

(1) Broaden base for social science support in NSF.

(2) Create foundation for humanities and the arts—some overlap exists between humanities and some social science fields.

(3) Called for clear relationship between consuming public and organizational structure set up to serve it. Suggested multiple support pattern.

(4) Social sciences should be represented on PSAC and on National Science Board.

B. Highlights of questioning

1. "By and large" NSF has tended to select social science projects which lend themselves to scientific method.

2. To extend that it is possible, quantification methods are used. Tendency is to seek objective and analytical approaches.

3. Broad consensus of need not required to produce results. Cited efforts of Wesley Mitchell through National Bureau of Economic Research on study of business cycle.

4. Social science needs—

(a) Organization to make best use of available funds.

(b) Strengthened departments within universities.

(c) More social scientists; cannot now meet requests from abroad for specialists.

5. Atom bomb seen as sociological and political problem.

6. Social science proposals presented to NSF reflect assumptions of what would be favorably received. As scope of programs is broadened, proposals expected to increase.

7. Agreed low level of support might be laid to social scientists for not bringing the problem to a head.

8. To extent that underdeveloped countries have infrastructure on which to build, social science contributions of United States can compete with those in physical sciences in competition with Communist bloc.

9. In general, United States needs to augment support of social sciences, both because of national and international aspects.

10. Could not say whether NSF is proper body to provide increased support for basic research in social sciences. Suggested inviting comments from well-informed persons.

July 21, 1965

Witness: Dr. Walter Orr Roberts, Director, National Center for Atmospheric Research.

A. Highlights of statement

Discussed National Center for Atmospheric Research and its relationship with NSF and with universities.

1. The National Center for Atmospheric Research (NCAR):

a. Study of atmospheric science developed after World War II when analytical tools were developed, particularly the electronic computer.

b. "Interdisciplinary" approach characteristic of atmospheric sciences.

c. NCAR origin was NAS study of 1958 which recommended creation of a National Institute for Atmospheric Research. NCAR established in 1960, by NSF, through a contract between NSF and University Corp. for Atmospheric Research. Management details reviewed; 13 original university members in NCAR, 21 today.

d. Facilities and visitor programs of NCAR open to all atmospheric scientists from member and nonmember universities, from private nonprofit and Government laboratories, both here and abroad.

e. Staff now 380, about two-thirds eventual size.

f. NCAR devoted to basic research, although need oriented:

(1) Laboratory of Atmospheric Sciences researches atmospheric dynamics, cloud physics, and atmospheric chemistry.

(2) High Altitude Laboratory studies atmospheres in outer space, and extraterrestrial influences on earth's atmosphere.

(3) Advanced study program—sponsors postdoctoral study in various research fields.

(4) Facilities program provides balloons, aircraft, and computers.

2. NSF-NCAR relationships:

a. NCAR has maximum scientific freedom.

b. Difficulties caused by insufficient funding, by contract restrictions, and regulations.

c. Saw need for experimental global observing network to be managed by Environmental Science Service Administration.

d. Discussed need for supercomputer, 100 times more powerful than any existing computer.

B. Highlights of questioning

1. University members of NCAR provide representative to council and/or trustees, and a cash contribution. Members must meet criteria for graduate instruction offered in atmospherics.

2. NCAR maintains wide contacts with agencies involved in weather science; NCAR scientists available to advise Government, industries, universities—anyone with scientific need to know about NCAR research.

3. Creation of NCAR reflects national realization of need for research in atmospheric sciences. Continuing NSF support of NCAR justified so long as it fills basic research needs not met otherwise.

Witness: Rev. Theodore M. Hesburgh, President, University of Notre Dame.

A. Highlights of statement

Statement presented a noncritical review of Foundation activity based on 11 years on the National Science Board and as president of the University of Notre Dame for past 13 years.

1. Board-Director relationships:

a. Harmonious relations between Board and Director.

b. Board has been well informed in detail of actions taken by Director under delegated authority.

c. Revised Board committee structure already proving useful. Sees Board as becoming even more effective in strengthening national science.

2. Concerning substantive aspects of NSF operations:

a. Common agreement that basic research support has had "enormous beneficial influence" on "national science enterprise."

b. Social science research support by NSF reviewed. Experience has shown that one agency can support both social and natural sciences. Problems and methodologies may differ but objectives and intentions are similar. In all fields, research is university-based, and standards and criteria "very much alike."

c. NSF educational activities of "very great significance to our national interest": (1) Fellowship and traineeships programs; (2) improvement of education through institutes to improve the teachers, and curricula revision. Two problems of teacher training: Half of high school teachers of science and mathematics have not applied for the teacher programs and many of new teachers are inadequately prepared.

3. Relationships between NSF and institutions of higher education—

a. Harmonious and mutually beneficial.

b. Foundation's careful and just evaluation of project proposals and honest administration recognized.

c. Institutional concentration of funds a problem. Need to maintain and support high-quality institutions and also to help raise levels of other institutions. Science development program has great promise.

B. Highlights of questioning

1. Concerning teaching by fellowshipholders, university experience has proved advisable not to have first-year graduate students teaching; also a danger that teaching may slow research and dissertation work. "* * * one of greatest needs in graduate students in all departments today is to get students through. Some students become perpetual students * * *."

2. Believes a majority of graduate students at Notre Dame go into teaching except in certain areas of chemistry and engineering.

3. Approved making Director a member of Board.

4. Special committees meet monthly; Board now meets about six times a year.

5. Staff turns out "enormously well prepared" papers. If special information is desired, have only to ask the appropriate staff person through the Director.

6. No problem getting information from people who are advocating a position. Usually alternative possibilities are offered to accomplish a purpose.

7. Concerning balance of representation on Board, what is really needed are "people who will take public responsibility with some background and knowledge and expertise on the total scientific effort as regards education and research."

8. NSF relations with NAS, OST, PSAC—very amicable relations with Academy which has guided Board in many areas; haven't felt any great tension in relations with OST and PSAC; "enormous support" from President's Science Adviser. PSAC and Federal Council offer "sounding board" for decisions which Foundation must make.

9. There ought to be relation between geographical distribution of centers of excellence and Federal research funds. NSF research distribution shows "fairly good correlation."

10. Always a danger that concentration of Federal research funds in certain areas will affect adversely others. Science development program expected to spread research and research support; must continue to support excellence.

11. Drop in percentage awards to social sciences since 1962 in relation to physical sciences not a reflection of waning interest but rather of fixed commitments in physical sciences.

12. Since social sciences do not require expensive physical equipment, more assistance and attention could be given to smaller colleges and universities in this area.

13. Board not too large; has great cohesion, very good committee structure, good geographical spread.

14. Board constantly concerned about need to support large projects such as Mohole, but aware that such support cuts into NSF's primary purposes with regard to basic research and education.

15. NSF must assume responsibility for gap filling. No other agency can.

16. No problem seem in Director's being responsible both to the President and to the Board.

17. President's Science Adviser attends Board meetings only on special occasions, when there was a question about his office or on broad matters of national policy.

18. No insurmountable conflicts between Board and PSAC or OST.

July 22, 1965

Witness: Dr. S. Dillon Ripley, Secretary, Smithsonian Institution.

A. Highlights of statement

NSF-Smithsonian relationships for basic research roles and the Science Information Exchange.

1. Basic research role of Smithsonian:

a. Smithsonian in basic research since establishment; a "forerunner" of modern graduate laboratory. Maintains "general concern" for basic research by in-house activity.

b. Research focused on specific needs, e.g., national program of salvage archeology in western United States in cooperation with Interior Department, on activities of Smithsonian Astrophysical Observatory and its Radiation Biology Laboratory, National Zoological Park, and the Smithsonian Oceanographic Sorting Center.

c. Present missions of Environmental Science Services Administration, Fish and Wildlife Service, and NASA originated in Smithsonian.

d. Program of grants of excess currencies for museum programs and relevant research recently started.

e. NSF support for Smithsonian activity include (1) funding visiting research appointments for undergraduate science students, (2) support of Science Information Exchange, (3) projects in oceanography, (4) Antarctic research, (5) endorsement of activities by NSF panels, and (6) use of Smithsonian staff to review proposals.

2. Basic research role of NSF:

a. Smithsonian concerned with institutional needs; NSF is concerned with national needs.

b. Agreed on necessity for increase in NSF budget to billion dollar level: (1) Supported 15 percent national basic research growth rate; NSF budget will have to be increased even more to accomplish its objectives; (2) agreed that mission-oriented agencies cannot be expected to support adequate basic research; (3) spoke to national need to support basic research to the limits of the public's need for new knowledge; (4) NSF must retain administrative freedom in management of funds.

3. Science Information Exchange:

a. Traced development since 1949 and current need for highest priority support.

b. Since NSF assumed total funding in 1963, former operating board of SIE is now advisory; policy, scope of activity, and procedures set under NSF agreement with Smithsonian.

c. Described "current awareness" information problem and rise of little "invisible colleges"—small groups of specialists in advanced fields who maintain mailing lists to keep informed of activity within field.

B. Highlights of questioning

1. Mission agencies need not confine activities to applied research; saw basic research as spinoff of benefits of applied work. Nor should NSF support applied research on theory it would sharpen objectives.
2. Discussed process by which SIE and individual investigator are kept reciprocally informed.
3. Wide public coverage given space program not now accorded to other aspects of science. More a lack of funds than of authority.
4. Lack of sufficient progress in certain fields not due to organizational problems. Was referring to lack of results rather than effort toward achieving objective.
5. About 35 percent of Smithsonian budget goes for natural science and research in addition to grants from agencies for performing certain activities.
6. Smithsonian's astrophysics activities "keeping up very nicely with general field."
7. Would increase financial base for basic research for which 15 percent growth would be applied.
8. Called "critical" the 5-year lag to achieve base which results from a 15 percent annual increase.
9. The subcommittee can help NSF achieve its goal by setting a "mood of generous willingness to support the science rather than specific details" of accounting procedures, etc.
10. Concerning coordination of SIE activities with other agencies, SIE focuses on basic research in process, while other agencies deal with completed basic and applied research and technology.
11. Prohibition against transfer of NSF funds for research to other agencies has adverse effects. Resulted in Smithsonian setting up its own grant program for original research, with selection made by ad hoc panel. System operating satisfactorily except that necessity to duplicate procedures of NSF has increased cost of program.

(Note that this is the only time in the hearings that congressional prohibition of NSF transferring funds to other agencies was brought up.)

12. On question whether information storage and retrieval should be centralized, deferred to COSATI. Inclined to allow competing groups. Problem of such urgency that there should be more rather than fewer attempts to solve problems.
13. Uncertain whether social science research projects included in SIE.
14. Criticism in Elliott Committee report referred to problems of input and feedback, due to failure of agencies to cooperate thereby reducing end use. Report has served to spur efforts by COSATI toward urging more complete participation.

July 27, 1965

Witness: Dr. Eric Walker, Chairman of National Science Board and President, Pennsylvania State University.

A. Highlights of statement

1. NSF responsibility and control:

a. NSF responsible to Congress through hearings and to Administration through the Director, Science Adviser, and Budget Bureau.

b. NSF responsibility to scientific community through National Science Board and advisory panels not as clearly defined or as continuously maintained.

c. Judgment by "peers" may have man judge proposals of friends or associates; dangers obvious but no alternative.

d. Reorganization Plan No. 5 of 1965 intended to increase flexibility in NSF relations with scientific community; uncertain of impact of divisional committees on operations under new arrangements.

e. Operation of National Science Board:

(1) National Science Foundation Act gave to Board major planning, policy, and operating responsibilities; some since delegated to the Director. Board "may delegate authority but not responsibility." Cannot delegate responsibility for (*a*) establishing general plans for NSF; (*b*) deciding direction NSF should go; and (*c*) making major decisions where specific Board concurrence is required.

(2) Since 1963, Board reorganized itself by establishing committees (*a*) to deal with present balance of effort, (*b*) to do planning for future, and (*c*) to deal with current administrative problems.

(3) Further steps believed necessary to maintain Board effectiveness:

(a) Assignment of full- time staff to Board—possibly one staff member for each of the Board's committees—among functions would be preparation of policy papers for committee discussion and action.

(b) Make Chairman of Board a full-time position—Chairman to establish policies and represent NSF in scientific community and among other Federal agencies; the Director to have full-time responsibility for management of operations. Could be implemented by making present Director the Chairman and put Deputy Director in charge of operations.

(c) Believe NSF has grown to point where there must be a "clear cut" separation between policymaking and operations.

(d) Full-time staff might assist in channeling divisional committee recommendations for Board consideration.

2. Uneven distribution and "apparent" concentration of NSF funds a problem:

a. No simple cure for the spiraling situation; both difficult and undesirable to fight excellence.

b. NSF programs to help correct situation are (1) science initiation grants, (2) institutional grant program, and (3) science development program. These means preferable to alternative of placing top limit on percentage of university's funds from Federal Government.

3. NSF and engineering:

a. Speaking as former president of Engineers' Joint Council, believe engineering has not received proper recognition from NSF.

b. Lack of understanding of true nature of engineering in Government and engineering educational institutions.

c. Federal Government role seen as financing and supporting necessary engineering design and testing of devices and systems where there is no immediate prospect of profit or major interest by a single company. Examples: instant mail delivery, transportation, water retrieval.

B. Highlights of questioning

1. Could not say whether it would have been better to strengthen Board earlier, rather than turn over authority to Director.

2. No specific date mentioned when Board's workload had reached a point where it could not function as it should. As NSF added programs and activities, work of Board increased—growth like an inverted pyramid.

3. His suggestions for Board revision could pose difficulty—clear definition of jurisdiction of staff needed as well as compatibility between Chairman and Director.

4. Legislative action to establish Board staff not believed necessary.

5. Agreed that complete separation of policy and operations impossible, but pointed out policy needs to be based on long-run considerations, while operations deal with problems of today.

6. Board may be at fault for lack of closer communication between Director's policy planning staff and Board's planning staff.

7. Confirmed existence of definite relationship between Federal funding and industry both being attracted to the best universities.

8. Existence of R. & D. in certain area not thought a factor in NSF distribution of funds to institution there through science development program.

9. Distribution of funds to industry has only indirect effect on institutions in that area.

10. Imbalance in distribution of Federal research funds cannot endanger existing centers of excellence—"* * * the excellent universities are so strong that things like this really cannot affect them."

11. Balance among fields of science represented by present Board "is very good."

12. Expressed personal belief that Board has been "very timid" in support of social sciences and also engineering. Establishment of Foundation for arts and humanities should make clear that social sciences are an NSF concern.

13. NSF role in solving major engineering problems is decision for Congress, the Board, and Administration to share. Believe NSF "could" and "probably should" do it. Real problem was absence of decision by Congress that these matters merited concern.

14. Was not aware of unresolved disagreement between Board and Director. In event of impasse about an activity, Board could insist on line item in request to Budget Bureau and the Congress.

15. If disagreement between NSF, Budget Bureau, and President's Office, disagreement would be resolved at President's Office level.

16. (Answered by Dr. Haworth.) Budget Bureau has turned down various NSF requests for program support. No single denial was a "significant" fraction of a total budget. New programs have been turned down or postponed. Reductions made for financial reasons.

17. Agreed that Board has not exercised its full authority. "Instead of innovating, it has been filling needs."

18. Agreed that Board's role with reference to overall scientific interest of Nation limited by (1) inability to dispute Presidential decisions on major expenditures and (2) failure to represent the overall scientific community of Nation including industry as well as universities and institutes.

Witness: William T. Knox, Chairman, Committee on Scientific and Technical Information of Federal Council for Science and Technology.

A. Highlights of statement

1. Statement dealt generally with NSF's relation to Federal Government's overall information program. Focused emphasis on information programs of COSATI and OST.

2. COSATI being reorganized into eight panels: Operations Techniques and Systems, Information Sciences Technology, Education and Training (already in existence). Under consideration are: International Activities, Information Generation, Information Users, External Relationships, and Budget and Statistics.

3. Size of Federal information program not easily determined because of difficulties in distinguishing between information activities and the research or engineering activities of which they are a part.

4. Rough budget estimates for information programs of executive branch agencies for fiscal year 1966 totaling $380 million discussed. Does not include public relations activities, nor actual experimental procedures, laboratory work, hardware costs, or procurement of items. Also publication not dealing with science and technology is not included.

5. NSF will support an estimated total of $18.4 million, or 4.5 percent of the $380 million total in fiscal year 1966, as shown in comparative functional breakdown.

6. COSATI's main functions have been to (*a*) identify multiagency problems; (*b*) develop an interagency consensus on amelioration or solution of problems, and (*c*) exchange information among Federal agencies.

7. Agency actions to improve information systems: (*a*) payment of "page charge" policy; (*b*) standardization of "microfiche" for technical reports; (*c*) uniform identification method for Federal reports; (*d*) subject category list for announcement of reports.

8. New central organizations set up with special functions: (*a*) Clearinghouse for Federal Scientific and Technical Information (Department of Commerce); (*b*) Science Information Exchange (NSF and Smithsonian); (*c*) National Referral Center for Science and Technology (NSF through Library of Congress); (*d*) National Standard Reference Data System (Department of Commerce).

9. Interdepartmental COSATI task group working on top-level effort to develop framework for improvement of complex of scientific and technical information activities:

a. Congressional committees assisting have been House Committee on Science and Astronautics, House Select Committee on Government Research, Ad Hoc Subcommittee of House Committee on Education and Labor, and Subcommittee on Government Reorganization of Senate Committee on Government Operations.

b. Task group has held special meetings with non-Federal organizations.

c. Efforts focused on formalized document-handling communication mechanisms.

d. Study team from System Development Corp. assisting.

e. Anticipate a report by fall 1965.

f. Approach has been to divide information systems into (1) complex of library systems and (2) complex of information evaluation and retrieval systems. Tentative courses of action in each component suggested.

10. Problems to be resolved:

a. Congressional decision will be needed about which parts of information network are Federal-responsibilities and which should belong to private enterprise.

b. Cost-controlling mechanisms.

c. Skilled manpower to man the information network.

d. Adequate information facilities on college and university campuses.

e. Most important, creation of a permanent mechanism for insuring optimum management of components of national information network. Several possibilities mentioned: (1) COMSAT-like corporation actually operating information network; (2) new Federal agency to handle all Government information functions; (3) new Federal agency for top-level planning and evaluation functions; (4) assignment of top-level planning and evaluation to an existing agency; or (5) continuation of present organization.

B. Highlights of questioning

1. On relationship of NSF to entire information problem, see agency as having responsibility in accordance with its mission—the support of basic research and education in sciences and engineering.

2. On question whether NSF should not have a more important rather than lesser role in the future, said NSF will be a serious candidate for task of top-level planning and coordination of the complex of information systems.

3. Question why in reorganization of 1962 NSF was not left with coordinating responsibility for information not fully answered.

July 28, 1965

Witness: Dr. Thomas F. Bates, Science Adviser, Department of the Interior.

A. Highlights of statement

1. Research role of Department of the Interior:

a. Interior's research relates to its primary mission as technical consultant and trustee of Nation's natural resources.

b. Federal R. & D. expenditures for natural resources program believed to be inadequate both to carry out responsibilities and in comparison with other Federal programs.

c. Interior's research programs diversified in kind, character and amount. It varies among bureaus, with some relying on in-house work while others rely more on extramural research.

d. Details of Interior's present and future research programs, including key issues, were presented in 1964 letter from Secretary Udall, and covered water resources, energy resources, minerals and geology, land resources, fish and wildlife resources, and ocean resources and ocean engineering.

e. Key issues identified were (1) strengthening and increasing Interior's extramural research effort with universities and industry; (2) establishment of information centers for resource fields; (3) need for analytical groups in resource fields to study resource analysis methodology, ascertain resource needs, and formulate national plans; (4) additional ecological surveys and research; (5) acquiring operational ability for ocean resources research.

2. NSF-Interior relationships:

a. Association varies, e.g., very little contact with Bureau of Land Management or Bureau of Outdoor Recreation; multiple contacts with Bureau of Commercial Fisheries, U.S. Geological Survey, Office of Saline Water.

b. NSF and Interior share mutual interests in life, physical and engineering sciences; also in (1) reciprocal use of NSF and Interior scientists on advisory panels; (2) Interior's utilization of NSF facilities, such as oceanographic vessels; (3) use of data collected and collated by NSF; (4) membership on interagency coordinating committees; (5) Interior's participation in NSF national research programs; and (6) attendance of Interior scientists at NSF-sponsored summer institutes and a limited use of Interior laboratories by NSF fellows.

c. Problem areas: (1) Lack of communications between Interior, NSF, and the universities; (2) lack of sufficient research support by NSF for areas of major concern to Interior; (3) NSF fellowship and traineeship programs attract best students from

Interior's research, and (4) lack of NSF management policy to assure adequate coverage of all science areas.

d. Suggestions for improvements included (1) establishing NSF-Interior coordination and planning groups for mutual problems; (2) setting up NSF-Interior-university committees to identify gaps and imbalances and seek ways to rectify situations; (3) increasing use of Interior scientists on NSF review and advisory panels; (4) attracting students to Interior's areas of research concern through (*a*) cooperative programs whereby NSF-supported students use Interior's laboratories and equipment, and (*b*) increase in traineeships allocated in areas of "environmental" and applied sciences.

B. Highlights of questioning

1. Formal and informal relationships needed to improve communications between NSF, Interior and universities. Limited funds and specific missions have contributed to difficulties, as has insufficient cooperative effort.
2. Supported increased NSF involvement in research of interest to Interior's mission; e.g., support of students at geology field camps, use of Interior laboratories and facilities by NSF supported students.
3. Research needs should be met in a logical, planned manner rather than allowing the direction of research to be determined by submission of proposals.
4. "Engineering sciences" cannot be precisely defined, in terms of "fundamental science" and "applied engineering." Agreed on importance of guidelines to redefine "engineering sciences."
5. Research constitutes a major part of Interior's R. & D. expenditures; will supply figures.
6. Congressman Brown suggested that expansion of research funds for mission-oriented agencies plus greater interagency coordination and integration might be preferable to expansion of NSF.
7. Although private funding for earth sciences is important in total support picture, it is largely for applied rather than basic research.

July 29, 1965

Witness: Dr. Arnold B. Grobman, Director, Biological Sciences Curriculum Study.

A. Highlights of statement

1. NSF and scientific education. NSF has significantly improved science education through support of curriculum study groups; but much remains to be done.

2. BSCS group programs:

a. "Debilitating" deletions from content of NSF texts because of content determination by the nonacademic marketplace contrary to majority of informed opinion.

b. Principal contribution of recent curriculum study groups has been opportunity for scholars and teachers of a discipline cooperatively to decide course content. Because of NSF support the materials are free of nonacademic pressure.

c. Have been able to get publisher contractual clause proscribing any changes. Biological sciences curriculum study (BSCS) books widely accepted.

d. BSCS work financed by NSF grants totaling $8 million over 7-year period. Have earned over $1 million from sales and royalties. BSCS summarized.

e. NSF contributions include (1) initial support for the idea; (2) arranging for scholars and leaders in various disciplines to become acquainted with each other's work; (3) sympathetic funding; (4) suggestions for improvement from NSF personnel.

3. Difficulties in BSCS relationships with NSF:

a. In absence of policy guidelines prolonged NSF indecision has adversely affected program.

b. Grants awarded for short and variable periods making well-organized planning difficult.

c. Delay until last possible moment in awarding grants.

d. Improper interference in internal operations by NSF officials.

e. Adverse decisions on grant proposals without opportunity for discussion between reviewers and BSCS.

f. National Science Board has not taken full advantage of experiences of NSF grantees.

g. Undue policy control exercised through fiscal controls.

B. Highlights of questioning

1. Influence of nonacademic marketplace agreed to affect teaching more in areas where controversy possible, e.g., less in mathematics and physics and more in biology, social sciences.

2. Re summer institutes, most important weakness is that many of those who instruct the teachers are not interested in changing their methods. Other problem is the people who need the institutes most do not or cannot attend.

3. Too early to observe more than beginnings of "wave effect."

4. Too much standardization is avoided by producing different versions, each of which allows choice and by encouraging use of any materials teachers want.

5. Objective is to prepare model materials. When other materials become equally good, BSCS will cease operations.

6. Examples of problems: NSF refusal to fund revision in 1965 of books written in 1963. Arguments over copyrights.

7. O. of E. and NSF roles. NSF began curriculum revision support first. Both now support curriculum projects, but in different fields.

8. Re questions of NSF general support of education via curriculum improvement, and examination of basic structure of elementary and secondary education, commented on need for better science courses and for widespread curriculum studies, with latter under more representative body than NSF.

9. NSF should increase its involvement in curriculum development "until there is some other way of handling this problem."

10. Alternative sources of support are private foundations or O. of E. "I suppose on balance, the best home would be the Office of Education, but I am not enthusiastic about it."

11. No other curriculum program of NSF has been as extensive as BSCS. Methods of NSF support are similar to BSCS.

12. Responsibility for curriculum of each subject as taught rests with local school boards. Federal attempts at guidance would be deemed Federal control.

13. Use of BSCS materials nationwide—slow in South, in New England, and New York.

14. Expect three-fourths of the schools to use BSCS materials by 1968.

15. Funds spent on comparable textbooks by commercial enterprise negligible compared to BSCS program.

16. For BSCS to operate as continuing organization, would require about $800,000. On alternative sources of funding BSCS has not requested funds from NIH; asked O. of E. for one grant but have not received it. Policy committee decided not to ask mission-oriented agencies for money.

17. Believes general curricula recommendations could come more properly from a Presidential adviser on education rather than from O. of E.

18. BSCS materials cannot be translated for use in other countries unless adapted in particular country. Adaptation committees have been established in a large number of countries. Philippine book off press, supported by AID, foundations, and NSF. Funding is major problem.

19. BSCS "as a group rather cool" toward audiovisual devices. Prefer to concentrate on materials so that student working in laboratory can learn by discovering for himself.

August 3, 1965

Witness: Dr. Jerome B. Wiesner, Dean of Science, Massachusetts Institute of Technology.

A. Highlights of statement

Made general observations on research in our society, and the role of NSF. Commented on important and pertinent testimony of previous witnesses.

1. Research and society:

a. Recent discussions, in which subcommittee has taken lead, have clarified thinking on various roles of science and technology, applied science and engineering.

b. National motivation for spending for basic research based on realization that basic research is investment in continued national well-being and progress.

c. General social problems: (1) Proper level of effort, (2) proper balance among various possibilities, (3) who should make the decisions, (4) how should Government intervene, (5) dangers of Government intervention.

d. Proper level of R. & D. expenditure:

(1) Discussions with economists inconclusive; precise answer impossible. "Rule of thumb" for R. & D. expenditures: "* * * one should go on making increased research and development expenditures until the marginal increases in productivity in the society equal the increased expenditures."

(2) Difficulty: impossible to measure contribution of basic research to economic growth of our society.

(3) If assume productivity increasing 3 percent annually, get a $20 billion increase in GNP as result of R. & D. Could afford "very much larger" increases in R. & D. budget than have been making.

(4) Doubtful that annual 15 percent increase in R. & D. expenditures of past 15 years can be continued.

(5) "In the basic research areas, I think this is presently the Government's policy, the administration's policy, and I hope the Congress will support it, to see that basic research continues to grow at something like 15 percent a year. I am not convinced that even that is enough * * *."

2. Role of NSF within general framework:

a. Concur with majority of witnesses that NSF share of basic research support is probably too small.

b. Does not know what NSF share should be—"* * * shouldn't be 80 percent and * * * 14 percent is too low. I think one can start to let it grow, in fact I gather this is happening, and watch it and see where we think we have reached a healthy balance."

c. Would preserve multiple sources of basic research support (1) to preserve quality of mission-oriented activities, (2) to allow experimentation, and (3) to preserve competition.

d. Geographic distribution one of most serious problems of NSF and the Government: Involves reconciliation between economic well-being of geographic areas, and agency mission demands to find the best competence wherever it exists and to support most promising persons where they are found. Useful to "push * * * very hard" programs to increase number of first rate teaching institutions.

e. Slow growth of NSF has been criticized. Timidity of Board and lack of aggressiveness of management may be partly responsible. Main reason is lack of strong Executive and congressional support because NSF lacked mission-oriented functions until it became involved in science education.

f. Increasing control, redtape, and bureauracy in NSF and other agencies criticized. Suggested examination to see whether bureaucratic trend can be reversed without relinquishing executive and legislative responsibilities. Part of problem is that Government fiscal practices necessitate frequent applications for support, wasting time and effort.

g. Fifteen-percent annual increase for basic research a composite of (1) natural rate of growth of science; (2) rate of educational process; (3) increasing salary scale of scientists and engineers, estimated at 5 percent per year; (4) increasing costs of apparatus. No alternative to this rate of increase if accept criterior to support "good basic research activities."

h. Inadequate support of engineering in general, and engineering research by NSF. Scientific and engineering community at fault in failure to recognize opportunities. Increased engineering research could solve major problems not likely to be undertaken privately and would train students in these fields.

i. Agreed NSF educational activities and new curricula development should be increased.

j. NSF and other federal funding inadequate for behavioral sciences, including communication sciences, economics, and social sciences.

k. Use of computers in science and engineering education has created a crisis in American universities:

(1) Must provide more computers on campus.

(2) Must support academic use of computers—uncertain whether NSF or O. of E. should do.

l. Agreed that some sciences are undersupported or underequipped.

m. Problems of small schools in teaching science need increased NSF assistance with curriculum development and possibly support of science faculties.

n. Government Science Corps suggested as source of teachers for small institutions, also assistants in Government laboratories, science attachés abroad, and part-time work in the larger universities and in industry to stay current.

o. Agreed NSF should increase international science activities, particularly cooperative projects.

B. Highlights of questioning

1. Despite multiplicity of Federal research activity, NSF can assume a larger role if a dominant position in policy and support of basic research is made clear through support for the fields of science for which it is responsible.

2. Concerning NSF organization—

a. Staff should be increased for some activities, e.g., educational R. & D. and in curriculum development.

b. Certain policy issues will have to be solved, e.g., how to support large scientific projects such as Mohole.

c. Director should be stronger vis-a-vis the Board. Although not recommended in Reorganization Act, consideration given to making Board a policy adviser and giving operating responsibilities directly to Director. Concept still worth consideration.

d. Negative reaction to suggestion for full-time Chairman of Board.

e. Any full-time staff for Board should be carefully limited in responsibilities.

3. Major overhaul of organization not needed. Board and Foundation staff have been reviewed, and Board has changed its structure.

4. Dr. Wolfle's suggestions for improvement of NSF's statistical functions "ought to be taken every seriously." Important for both NSF and OST, and other agencies.

5. Difficulties in support of behavioral sciences due partly to interpretation of "science," fear of criticism of work that suggests manipulation of public opinion, and uncertainty among behavioral scientists concerning their needs.

6. Did not believe that NSF should recapture coordinating functions now in OST.

7. Computer problem is "several times the scope of the Science Foundation's ability to deal with."

8. The 15 percent increase will not attract too much scientific manpower into basic research.

9. No opinion about balance between NSF support for basic research and science education. Balance satisfactory except insufficient support of educational R. & D. while he headed OST.

10. Impatient with rate of growth of NSF which has not yet compensated for the slow growth during first decade.

11. NSF international science role could include leadership in education abroad. Other agencies such as AID should have interests.

12. NSF mechanisms are "really fairly good" for allocation of funds among various fields.

13. Primary function of NSF should remain the support and stimulation of basic research and quality scientific education.

14. Supplied for record views on combining OST and NSB and the Foundation to coordinate scientific research of Federal Government.

15. Not necessary to amend National Science Foundation Act to strengthen activity in certain areas.

16. Board authority sufficient to go directly to President or to Congress in opposition to the NSF.

17. Re roles of NSF, O. of E., and NIH. NIH has no legal responsibility or authority for education. NSF has looked to NIH to support health-related research and has concentrated its effort in other fields. NSF might not have developed its educational program if O. of E. had been more aggressive in science.

August 4, 1965

Panel Discussion on Scientific and Technical Manpower

A. Highlights of statements

Bryce Crawford, Dean, Graduate School, University of Minnesota

Sees research assistantships, teaching assistantships and nonservice appointment fellowships all important. Notes benefit of teaching experience. Ideal system would encourage any graduate student doing research to do some teaching with also an adequate amount of nonservice support to take an "undistracted slice of time" for his studies. Would not make teaching mandatory.

William A. Douglass, President, Careers, Inc.

If some 60,000 engineers and scientists apply to his concern for change in jobs in the last 2 or 3 years, there is something in need of discussion. Identifies as subjects needing attention: technical obsolescence, continuing education, mobility, proper use of skilled aliens.

James Killian, Chairman of the Corporation, MIT

Re supply and demand for scientists and engineers, shortages more likely to occur in science, engineering, medicine, and mathematics than in humanities, social science, and law. Summarizes Killian Report (NAS study): risk is having too few rather than too many students choose science and engineering; proportion of colleges committed to science and engineering not robbing humanities and other fields.

Adequate manpower information is a problem. Repeated recommendations for single agency or office with responsibility and authority for coordinating the various Federal efforts to provide adequate and continuing information on scientific and technical manpower. More interpretation and projections needed. NSF should be a partner in such a central effort.

NSF could have taken earlier initiative in aid to potential centers of excellence and "creating new innovative programs." These are needed now, take a long time to build. We are overdependent on a few centers today which cannot turn out enough high quality graduates without growing too big.

Identifies NSF teacher training and curricula development as "breakthrough" in improvement of education. Calls for more support.

Leonard A. Lecht, Director of the National Goals Project, National Planning Association

NPA studies of national goals anticipate total spending of $39 billion a year by 1975 (in 1962 dollars) for R. & D., an increase of almost 2.5 times from 1962 to 1975, with largest increase in the civilian economy area—health, transportation, air pollution, water, and small business. Forecasts 125 percent increase in number of scientists and engineers from 1960 to 1975, requiring an increase in manpower pool of 1.75 million between 1962 and 1975.

Calls for national priorities planning in Executive Office of the President to identify the scientific and engineering skills required for all major national activities—public and private. Demands previously balanced by the market, but large public programs have distorted balance and make Government action necessary.

More information needed. Why the relative decline in degrees in engineering—from 10 percent in 1958–59 to 7.5 percent in 1962–63: how convertible is technical manpower from defense and space to civilian use.

Foresees increasing need for trained and educated manpower. Improve supply by positive steps to develop and expand manpower research and planning.

Frederick Terman, Vice President, Stanford University

Re manpower shortage, thinks much concern misdirected toward numbers rather than quality. No real lack of warm bodies, but there is. and has been, continuing shortage of engineers and scientists with high training and ability. Too few students continue into graduate study. As a result, jobs often filled with people with less training than needed, which downgrades effectiveness of our industrial economy, causes overruns and failures, weakens our position in international competition in science and technology.

Notes actions to carry out PSAC recommendations: new training grant program of NSF, NASA trainee program, NDEA activity. But these not enough and fall below PSAC targets.

Financial support essential for graduate students. Thinks NSF educational spending distorted; would prefer to see money going to high school science program invested instead in support of graduate education in mathematics, physical sciences, and engineering.

M. H. Trytten, Office of Scientific Personnel, National Academy of Sciences

Notes need for more study in depth of manpower. NSF data collection so demanding that it has little opportunity for studies in depth about what the statistics mean. Favors Wolfle's proposal to establish a separate entity to determine the meaning and significance and relationship of the factual information being gather. Calls for future NSF support of the present privately financed Commission on Human Resources to do this.

Notes increased flow of students into graduate study because of various Government financial support but wonders about adequacy of information concerning the quality factor. Suggests some sort of post audit to qualify, perhaps via the graduate records examination.

Bowan C. Dees, National Science Foundation

Defends NSF statistical services in face of absolutely insatiable desire by users for more information. NSF has known what was needed, wanted to do it, but could not always get resources. Warns of bringing low quality students into the science education program and the need for a long term view.

B. Highlights of discussion period

1. *Undergraduate education.*—Killian thinks science preparation in precollege schools and improvement of curriculums at undergraduate level is of fundamental importance, and should not be delayed.

2. *Retraining.*—Needed by men 35 years of age and older. Notes most industrial education is for younger men, not older ones. Government will not pay costs of preemployment retraining of competent people for work on contract projects. Better fundamental science and engineering education seen as remedy to obsolescence. No Government responsibility to the individual for retraining; Government, however, should provide opportunities for better training to produce more versatile people, and to recognize problem of additional graduate study. Proposal for free public retraining from ages 35 to 38 to everyone who wishes it. Seconded by Douglass for a demonstration.

3. *Centers of excellence.*—Needed so that those with the greatest potential must be supported right now wherever they may be, with attention to geographic distribution later. More centers needed because there isn't enough capacity now in graduate schools for future requirements. Developing new centers takes a lot of effort over a long period. Need to upgrade other institutions to become potential centers. Warning against forced growth and premature furnishing of fellowship support.

4. *Two-year training.*—Too many people in 4-year college who should be in 2-year institution. Excellent 2-year men needed as well as excellent 6-year men.

5. *Single manpower agency.*—NAS recommendation recalled by Killian for central responsibility for stimulating and coordinating planning by Federal Government for scientific and engineering manpower, and developing integrated collection and analysis of information. No present place to initiate, instigate, and stir up. NSF had considered this before NAS report and a group has been set up to concern itself with science resources of the country generally, is beginning to make progress. President's Manpower Committee has Cabinet rank and responsibility to consider ways and means of setting up more centralized evaluation.

6. *Econometric models.*—Gross absence of adequate mathematical models of the economy. NSF trying to develop growth models in two areas: one at Ann Arbor and one still unassigned. Relationship of R. & D. and economic growth a very important level of research.

August 5, 1965

SEMINAR ON SCIENCE ON SMALL COLLEGES

A. Highlights of statements

1. Dr. Sanford Atwood, Emory University:

a. Small colleges valuable source of graduate students in sciences; act as "grassroots centers for the selection and training of scientifically superior students."

b. Eighty percent of Emory's B.A. and B.S. male graduates go on to graduate study.

c. Illustrates importance of NSF High School Institutes, NSF undergraduate research participation program, and teacher training activities.

d. Strongly endorses NSF programs, wants them expanded to develop competency of small colleges as well as large universities.

2. Dr. James P. Dixon, Antioch College:

a. Small liberal arts college seen as an important source for recruitment and pretraining in the disciplines of physical and social sciences.

b. NSF concentration on undergraduate support on preprofessional training may miss potential creative scientists who are pursuing general education at undergraduate level.

c. NSF failing to support education of citizen leaders equipped to "manage humane science policy."

d. Small college physical and social science faculties viewed as second class by universities because of limited research opportunities; extremely difficult to hold faculty of quality needed to train students for graduate study.

e. Proposes:

(1) Institutional grants to small colleges to develop undergraduate students and faculty.

(2) Teaching interns.

(3) Groupings or consortia of small colleges.

3. Dr. Katherine McBride, Bryn Mawr College:

a. Presents case study of variety of NSF programs in Bryn Mawr.

b. Looks to NSF to support basic research and graduate students. Cooperative fellowships and graduate traineeships very helpful.

c. Discusses NSF undergraduate research assistance and NSF institutional base grants.

4. John E. Sawyer, Williams College:

a. More capacity for Ph. D. training than there is supply of students. Small colleges a needed source.

b. Sustaining science in small colleges emphasized and also importance of liberal arts education to scientists.

c. Small colleges cited as source of science teachers.

d. Endorses emphasis on excellence and ability in selection among proposals.

e. Mentions five areas needing NSF support:

(1) Science buildings.

(2) Equipment and research assistance.

(3) Balancing teaching loads.

(4) Professional contact and development.

(5) Summer compensation.

5. Dr. Richard H. Sullivan, Reed College:

a. Praises NSF competence.

b. Stresses small colleges as source of science teachers.

c. Favors institutional and undergraduate support programs of NSF.

d. Calls for strengthening of faculties with NSF support through faculty programs and curricula development programs.

e. Favors undergraduate research participation.

f. Suggestions:

(1) NSF support to small colleges get more involved in information transfer by feeding scientific information through undergraduate faculties. NSF support for small college education of citizens in public issues of science.

(2) Establish central data bank for information of small college faculty seeking research support. Provide orientation for all Federal science support.

(3) Discretionary funds to colleges to support students that fellowship and traineeship support "may have overlooked," through reliance on impersonal indicators.

(4) Expand institutional support for centers of excellence.

B. Highlights of questioning

1. National Science Board:

(a) Meetings: Monthly meetings of NSF special committees provides extensive opportunity for discussion and exchange of opinion with NSF. (McBride)

(b) Full-time chairman opposed. (McBride)

(c) NSF staff: NSF staff found time to prepare materials and meet with Board. (McBride)

2. Fellowship limitations: Will cause loss of talent unless other support available. (Sullivan)

3. Undue dependence on NSF: NSF supports only 2 to 3 percent of small college budget versus 20 to 30 percent in large universities. No undue or inappropriate Federal influence. (Sawyer)

4. Consortia: Favored by Dixon; possibility of NSF support via contracts with consortia. Could be used to administer programs. (Dixon)

5. Disadvantages of matching requirements. (Sullivan)

6. Subprofessional training: Technical schools not in competition with small colleges. (Atwood)

7. Overhead: Smaller colleges can live with present limitations. (McBride and Sawyer)

8. Computers: Important to university research and training. (McBride) Training needed. (Sawyer)

9. Social and environmental science support: Research opportunities needed. (Dixon) Social sciences starved. (Sullivan) Restraints on social science in world affairs. (Brown)

10. NSF-university relations: Should be two way. Presently, colleges and universities go to Washington as supplicants; would have NSF actively seek to interest colleges and universities in its programs through regional offices. (Atwood) Field visits and regional conferences noted. (Sullivan)

11. Teacher training: The most rewarding of NSF's programs. (Atwood)

12. Starter grants for young faculty. (Atwood)

August 19, 1965

Witness: Dr. Leland Haworth, Director, National Science Foundation.

A. Highlights of concluding statement

1. Social science: NSF support increasing proportionately more rapidly than other programs; up 6.6 times since 1960.

2. Fellowships in engineering: Ratio of successful applications for engineering fellowship to total applications very close to ratio for applications in sciences. Gives details and growth trends. Text of statement on graduate education in engineering.

3. Royalties on texts: Actual royalties received for BSCS about one-half million dollars. Additional public benefit is printing of extra copies of preliminary books at cost for use by nonparticipants. Total royalties for all texts about $2 million with another million in escrow.

B. Highlights of questioning

1. Student support: Defined and discussed graduate fellowships, traineeships and cooperative fellowships. Plan to drop cooperative fellowships, if National Science Board concurs, and shift this support into the regular fellowship and traineeship programs.

2. Authorizing legislation: Haworth has no opinion on benefits of authorizing legislation. Endorses interchange of information between executive and congressional committees. Tells of experience with Joint Committee on Atomic Energy probing in depth into some phases of AEC program each year. These were unquestionably of great value to the Commission. Penetrating hearings in depth on the various aspects of an agency's programs are a good thing.

3. National Science Board: Opposes separate staff, would prefer to see present staff given more time to assist Board. Advisory role considered, Haworth has no strong feeling pro or con. Notes problems of daily decisions relieved by delegation of operating authority from Board to Director. Thinks academic community prefers present role of Board.

(Text of W. W. Houston's letter about Board.)

4. NSF self-examination stimulated by hearings. Regular self-examination through NSF Planning Council and NSF Associate Director for Planning. Notes science development program a product of this planning. Presently considering long-range role in science education.

5. Scope of NSF Charter: "* * * the broad charter that the Foundation has has been a very fine thing, * * * would hate to see it restricted in any sense."

6. Balance function: Self-examination caused by hearings has led to change in view of balance wheel idea from hole plugging to desire that NSF be in the forefront in taking account of the capabilities and sup-

port of other agencies in meeting its responsibilities for scientific health of the country.

7. Mohole and applied research: Justifies large-scale engineering for project Mohole because basic research is its final purpose. Would not be appropriate for NSF to go into engineering development except as means to end of doing basic research. "This is, to my mind, one of the reasons that we have to be cautious about thinking about getting into applied research."

8. Mohole project: Haworth stresses mantle penetration is only one of many assignments for Mohole facility and that whole cost should not be charged against the mantle project. Says present estimate to get facilities into being is $75 to $80 million. Analogy with Brookhaven and Berkeley accelerators.

9. Big science: NSF has basic research role in big science. Notes fear that big science competes with academic research for funds, but thinks NSF must support its share of big projects. Re NSF future support for big science, can answer this better when all NAS reports are in. Mentions astronomy and computers. Note question of Mr. Vivian about specific big projects.

10. Growth trend for basic research: Allocation of the 15-percent increase recommended for academic research would be determined largely by activity of various fields of science in submitting proposals. Expects biochemistry to be active. Sees self-governing mechanism. Notes NSF can and does recognize areas not being supported and seeks to attract attention and proposals.

11. International science: Four areas of NSF participation:

a. International cooperative ventures; e.g., IGY, etc.

b. Procurement of special research capability available only abroad.

c. Support of science and science education in developing countries as foreign policy objective.

d. Grey area where for foreign policy reasons it may be desirable to support foreign science even though capability exists here.

12. Reorganization Plan No. 5: Haworth has not yet crystallized plans to delegate his authority to staff. Mentions delegations to his Deputy Director. Authority delegated to Director by NSB seems redelegable.

APPENDIX 2

RESPONSE BY WITNESSES TO QUESTIONS SUBSEQUENTLY SUBMITTED BY THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

RESPONSE BY DR. LELAND J. HAWORTH, DIRECTOR, NATIONAL SCIENCE FOUNDATION, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

NATIONAL SCIENCE FOUNDATION,
OFFICE OF THE DIRECTOR,
Washington, D.C., August 16, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research and Development, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. DADDARIO: Please find attached my responses to the questions that you sent me on July 17. Extra copies are included for you to provide your subcommittee members and staff.

I am sorry that I was not able to complete my answer to question A-3 regarding any possible role of the Foundation in applied research in time to include it with this transmittal. Question A-4, the answer to which is dependent on that to A-3, has also been omitted. I hope to have these responses available by the time I testify on Thursday, August 19.*

In preparing my replies, the Foundation staff and I have, of course, been influenced by our knowledge of past actions taken and points of view expressed by the National Science Board. However, I should make it clear that the opinions are my own and do not necessarily represent the views of the Board. Indeed, except for a few fragmentary conversations with a very few individual members, I have not been able to discuss the questions with the Board.

I shall be happy to provide additional comments on any of the questions if you so desire.

Sincerely yours,

LELAND J. HAWORTH, *Director.*

*This material, subsequently provided, is included on p. 914.

CONTENTS OF RESPONSE BY DR. LELAND J. HAWORTH

A. General Policy and Authority

A-1. In the light of your participation in the committee hearings, would you please review for the record what you consider the National Science Foundation's basic role is or should be in formulating, coordinating, or evaluating national science policy?

"National science policy" is a constellation of interrelated policies. These policies may be grouped together under this singular term because they affect, directly or indirectly, the level, substance, and conduct of scientific activities in the United States, the opportunities for and content of education in the sciences, and the utilization and development of the Nation's resources for science. Science policies are also shaped by State and local governments and by nongovernmental institutions, enterprises, and organizations. It is appropriate, therefore, to speak of a constellation of both public and private science policies.

I make this point because I believe that the Foundation has a role to play not only in connection with the science policies of the Federal Government but also with those of non-Federal public and private sectors of the Nation. The scope of the Foundation's role is dictated by its statutory responsibility "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." The Foundation's overriding concern is to assure the progress of scientific knowledge and the strengthening of the manpower and institutional capabilities for science in the United States through policies and programs directed toward basic research and education in the sciences. But this concern does not rest with the Foundation alone. It is one which the Foundation shares with other Federal agencies, levels of government, and organizations and institutions in the private sector.

The Foundation's own policies and programs are designed to maintain and enhance the health and vigor of basic research, and to expand the opportunities for education of high quality in the sciences. It is our hope and belief that NSF can assist, through these efforts in strengthening the scientific and educational capabilities of academic institutions. I believe that what NSF does directly through its own operations it should complement by an active leadership role in developing, evaluating, and proposing alternative policies by which the Federal Government as a whole, the State and local governments, and private institutions and organizations could contribute to the realization of these primary objectives. This in my view is a basic and continuing Foundation role. It should and can be fulfilled in several ways.

One is by providing improved essential information about the Nation's resources for science and their development and utilization. Another is by undertaking analytical studies of the dynamic, diversi-

fied system by which research and education in the sciences are supported. A third is by conducting or arranging for the conduct of investigations dealing with the resources required to capitalize on science and to guard against the neglect of any one field or subfield in the sciences. Still another is by designing, and where possible testing, experimental programs of a pioneering and innovating character with respect to research and education in the sciences.

In short, the Foundation should, in terms of the Nation's overall stake in science, play a vital part in developing an understanding of the possible courses of policy action open to it. NSF should lay the basis for, and point the way toward, policy recommendations of a broad, overall character.

On the coordination of national science policy, where specific responsibilities fall to OST, FCST, and BOB, the Foundation has a basic role to fulfill. This, too, takes several forms. The Foundation should continue—and where possible strengthen—its formal and informal cooperative relationships with governmental agencies, academic institutions, and concerned voluntary organizations and professional societies. It should continue to contribute to, and help strengthen, the coordinating functions performed by OST, FCST, BOB, interagency committees, and PSAC through the provision of essential data, staff assistance, and analytical studies on significant policy problems and issues. Finally, it should undertake to initiate and propose policy guidelines in the Nation's total effort to upgrade its research and education in the sciences.

With the Reorganization Act of 1962, the responsibility for evaluating the scientific and technological policies and programs of Federal agencies was assigned to OST. In this area, consequently, NSF's role must be defined as a contributory one. This role is expressed in its responsibilities for providing: information on the funding of research and development and knowledge about the Nation's resources and requirements of manpower and institutions for science; assessments of the probable consequences of existing policies for these resources; and suggestions for improvements.

A-2. To what extent is the Foundation limited in functioning as an operating agency? Why? Should it be given greater operational authority?

The Foundation's operating authority is limited by section 15(c) of the National Science Foundation Act of 1950, as amended, which states:

> The Foundation shall not, itself, operate any laboratories or pilot plants.

This restriction extends only to Foundation operation of laboratories or pilot plants with the aid of Federal personnel. Since any operations which the Foundation might desire to have carried on can be accomplished satisfactorily through the grant or contract mechanism, we see no particular need for greater operational authority. Our experience with the national laboratories (and analogous experience by the Atomic Energy Commission) demonstrates the feasibility of meeting operational requirements through contract arrangements.

A-3. Should the National Science Foundation be given added authority to concern itself with applied science? If so, to what extent?

A-4. Should any added authority along the lines of A-2 or A-3 be made a directive—or merely permissive?

The National Science Foundation, in the national interest, must consider means to foster the overall development of science, including education, in academic institutions. While the role of applied research enters into this consideration in many disciplines, it arises with particular urgency with respect to engineering and the social sciences.

Many people today believe that more applied research at engineering schools is necessary to develop the type of engineers needed to adapt new scientific knowledge to engineering applications for the welfare of the country. Limiting support for research to that which is purely basic interferes with the ability of these schools to enrich their theoretical curriculums with more applied research opportunities. Similar considerations apply in certain of the social sciences.

Moreover, it is the nature of scientific research that findings may be unexpected. It is important, therefore, for an investigator to be able to follow promising leads developed in the course of a basic research project even though this takes him into applied science. In this way, totally new and fruitful frontiers in basic science and applications of great value to the country may become evident.

I think, therefore, that in the national interest it is important that the Foundation more broadly support research at educational institutions, both to assure better training for young scientists and engineers and, also, so that worthwhile research which scientists and engineers at academic institutions wish to pursue may be undertaken on a broad spectrum.

In an effort to define basic research in the engineering sciences so as to best meet these needs of science and engineering within the original intent of Congress as expressed in the NSF Act of 1950, the National Science Board, in 1962, resolved that:

> * * * the National Science Board considers that intellectual pursuits at educational institutions intended to advance significantly the basic engineering capabilities of the country are eligible for support by the National Science Foundation as basic research in the engineering sciences. Such work must be of a true scientific nature and not routine engineering practice, and must meet the usual NSF standards of originality and excellence.

While this clearly covers substantial parts of the research which should be supported in the field of engineering, it does pose many problems of application to particular situations which lie in a gray area of permissibility. Furthermore, similar problems are increasingly arising in supporting research in the social sciences, as the Foundation's programs in this area grow.

I have discussed this situation with the Executive Office of the President and it was agreed that these problems connected with the broad support of research at educational institutions warrant serious consideration within the next few months in the light of the Foundation's responsibilities for improving the caliber of educational institutions. In any event any legislation in this area should be permissive and not mandatory. I would like to stress further that even if the NSF Act were amended to permit support of applied research in academic institutions, I am confident that the Foundation will continue to regard

its primary research mission as the support of basic scientific investigations.

Apart from the particular considerations involved in the support of applied research at educational institutions, opportunities which need to be pursued in the national interest outside academic institutions will arise in areas of applied research where adequate support is not available. Industry may fail to initiate or support such research, for example, because of the expense involved coupled with the remote likelihood of the results of the research being of benefit to any single company. Government may fail to support the research because it does not fall clearly enough within the mission of any particular agency. However, this area needs much more consideration. As a first step in this consideration, the Foundation is contemplating sponsoring studies to examine the contribution which augmented and organized applied research might make toward solving some of the pressing social problems, how such efforts might be marshaled and what role various agencies of the Federal Goverment might play in them.

A-5. Should NSF assume a more active role in the support of international science programs? In basic research only? In applied research? In scientific development? Might not U.S. aims, other than the development of pure science, be furthered thereby?

Several witnesses have testified in this series of hearings to the effect that the United States should be playing a more dynamic role in using science as a means of furthering our foreign policy objectives, and that our own domestic programs in science and science education would benefit from a larger number of cooperative scientific ventures. I believe that both of these points are well taken. With respect to the role of NSF in creating a more satisfactory situation in this regard, it would be necessary to provide both broader authority and increased appropriations if NSF were to add new responsibilities beyond its present scope, which is primarily limited to support of domestic activities.

NSF has never been heavily engaged in the support of international scientific activities, but almost since its inception there have been elements of its efforts which have involved it in international matters to a degree. NSF has, of course, participated very actively in a number of international cooperative science programs, such as the Antarctic research program, the International Year of the Quiet Sun, and the International Indian Ocean Expedition. These are programs in which each participating nation has funded its own work. In this response to question A-5, we will mainly deal with other kinds of international science programs.

NSF has had enough experience to be able to foresee some of the challenges that lie ahead. To some extent, with no change in its present mandate, the Foundation will find it desirable and at times necessary to further extend its international role; it may be helpful to review some of these activities in order to gain perspective.

With regard to basic research abroad, NSF could assume a more active role; but an increase in such support raises two issues. First, the Foundation now funds only about two-thirds of the meritorious domestic research proposals submitted, and the allocation of funds for support of research abroad might be questioned by U.S. scientists

and the Congress. Second, the gold outflow problem is involved. In fiscal year 1965 NSF was limited to $700,000 for support of research in certain foreign countries; the Foundation spent about $637,000 in *all* foreign countries.

The Federal Council for Science and Technology has requested all agencies to examine their support of research abroad and to support only those projects within the agency mission which will contribute to science in the United States. Other agencies of the Federal Government, including the Department of Defense, support mission-oriented research abroad, some of which is of such a nature that it could also be supported by the NSF. The President's Science Advisory Committee has suggested that our foreign relations would be better served, at least in some countries, if research support were given by a civilian rather than a military agency.

One way of increasing NSF research support abroad which would not involve a large increase in direct grants to foreign institutions would be to encourage more cooperative programs between American and foreign universities. The foreign university would be expected to contribute significant funds to the project, NSF funds going only to the American university. Programs of this sort not only tend to increase support of research in foreign universities by the government involved, but also enable outstanding scientists in the two countries to work more closely together. Science everywhere profits from such endeavors.

NSF could also play a more active role in science education. Developments in science and science education in any country are of universal interest. This has been demonstrated by the interest aroused abroad by the new developments in science education in the United States. For example, the new course content materials may turn out to be one of America's most valuable exports. At least 40 countries are now using these materials, or modifications of them, in their school systems; and many texts and laboratory manuals have been translated into other languages. Some scientifically sophisticated countries are finding these course materials of great interest. The United States could profit if there were even greater cooperation than now exists between American scientists and their foreign colleagues in this field.

NSF could also increase its activities with international and regional organizations which have scientific programs of importance. At present there is no central point in Government which has the responsibility for U.S. participation in and "backstopping" for their science programs. NSF could make a significant contribution if it were assigned such responsibilities.

The question of a more active NSF role in the support of international science programs in applied research is, of course, dependent upon whether NSF's domestic program is expanded to include more applied research. In any event, however, I do not believe that NSF should become involved in the support of applied research abroad in the near future.

NSF hopes to be able to work more closely with AID to help improve science education, scientific research, science in general, and to a certain extent, technology in the developing countries. In this area

the Foundation could also work much more closely with multilateral agencies (such as UNESCO) which have relevant responsibilities.

Through two agreements with AID, NSF now has programs designed to help improve science education at the secondary level in all of Latin America and in higher education in the five Republics of Central America. Experience in Latin America suggests that NSF has a most unusual opportunity to help developing countries adopt modern methods in the teaching of science. Under present law this can be done only with money supplied by AID. Discussions with AID staff, in Washington and abroad, suggest that requests will be made for NSF advice and help in science education in several developing countries. NSF will respond as fully as it can to any such requests.

One important area in international science closely related to science development is now being neglected. NSF, with congressional approval and a modest appropriation, could make a positive contribution. This is in the so-called gray area—which may be defined as the support of scientific activities abroad where foreign policy considerations are at least as important as scientific ones. There are many good scientists in developing countries whose research is hampered by lack of equipment or research assistants. In many of these cases a modest grant would pay dividends in terms of research results and international amity. For example, many foreign scientists do graduate or postgraduate work in the United States. Hundreds of them do not return to their countries because of the lack of opportunity to do research there. A program designed to give properly qualified foreign scientists a modest grant would encourage these able people to go back to their own countries and develop scientific research and education centers which their countries need.

A-6. The charts you presented at the hearings included a graph on trends in Federal obligations for scientific research (chart No. 8) and a bar diagram on the total NSF program by research areas (No. 13). Do you see a need for any change in the modest Government participation in social science research? Should NSF concern itself with the social or behavioral sciences; or should its role, in your judgment, be confined to support of the natural or physical sciences?

> *C-5. In view of your statement that the Foundation's role in the promotion of basic research should be a more active one, how has the Foundation currently defined its role for the support of research in the social sciences? What is the scope of coverage in this area and the subareas supported, and what are the plans of the Foundation for future support of the social sciences in relation to other fields?*

Government participation in social science research should increase, and NSF should play a significant role in that increase.

NSF programs in this area have now reached a stage where further expansion is warranted. The attached chart provides data on the relative increase in support for the social sciences as well as the other sciences supported by NSF. NSF support of research in the social sciences has been limited to support of that element of investigation in these fields which can be designated *scientific*; this means that the major area which has been excluded from eligibility for support by

NSF is "policy-oriented research." This is consistent with the NSF role as an agency concerned with the promotion of science.

NSF should not be confined to the support of the natural or physical sciences. It is not now so confined. Experience has shown that the social sciences have many areas of overlapping interest with the natural sciences and profit by association with them. Subjects and techniques of investigation vary among the many different sciences, but the spirit of objective, analytical inquiry is common to all. Moreover, the social sciences are regularly established parts of the academic scientific enterprise, and as NSF assumes responsibility for the health and growth of college and university-based research and training in the sciences generally it should respond in a way which conforms to the patterns chosen by the academic community at large with as few artificial boundaries as possible.

The basic research and related activities which the Foundation currently supports in the social sciences include scientific archeology, social and physical anthropology, economic and social geography, demography, economics, the history and philosophy of science, linguistics, political science, psychology, and sociology. Within these broad disciplines the Foundation strives to support activities that are scientific in method. The proportion of research in social science subjects that is objective, independently verifiable, and subject to useful generalization has been growing in recent years. Indeed, we believe that the support afforded by the Foundation has been a factor in accelerating this important advance. The role of the Foundation, therefore, is to further encourage the development of scientific methodology in the social sciences and provide adequate support for scholarly research and studies—especially in the academic setting.

The Foundation's involvement with the social sciences has been a gradual development over the past decade. The pattern of seeking NSF support for basic studies, while well established in the natural sciences, is just beginning to emerge in the social sciences. For this reason the scope of the Foundation's interest in the social sciences is not completely known to the academic community, and as a result the Foundation is not yet fully aware of all of the important needs in the social sciences as a whole or in the separate disciplines. We, therefore, cannot confidently assess the degree to which the Foundation is currently meeting such needs.

The pattern of Foundation support in the social sciences in fiscal year 1964 appears in the following table:

Grants for basic research in the social sciences, fiscal year 1964

Subfield	Number of grants	Total amount
Anthropological sciences [1]	108	$2,699,305
Economic sciences [2]	48	2,207,164
Sociological sciences [3]	60	2,620,307
History and philosophy of science	36	572,800
Special projects and resources	9	1,278,600
Total	261	9,378,176

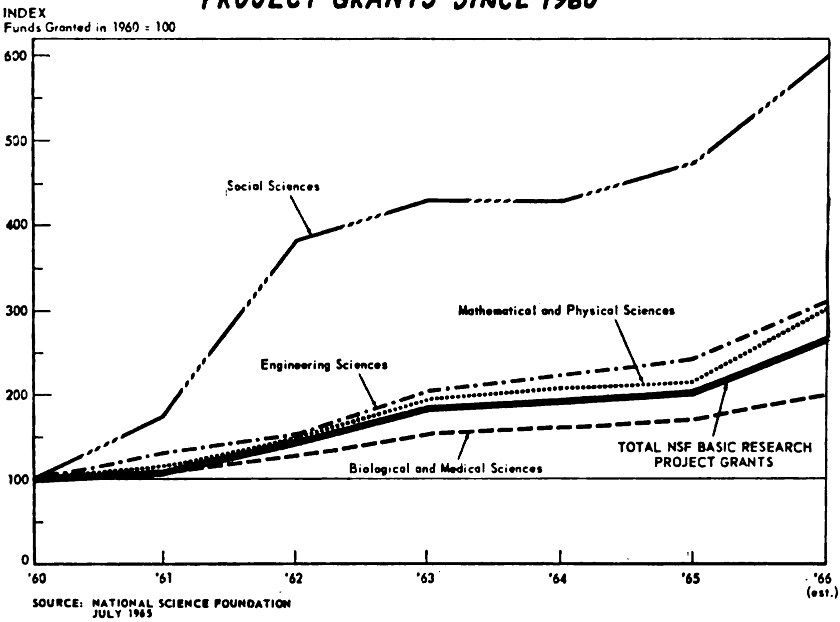
[1] Includes archeology, social, cultural, and physical anthropology, and linguistics.
[2] In addition to economics, economic and social geography is included.
[3] Includes sociology, social psychology, political science, and demography.

The future level of Foundation support for research in the social sciences will be dependent upon a number of factors. Among these are:

1. Total funds available to the Foundation.
2. The intellectual quality of proposed research.
3. The importance of the research relative to its impact on education, the social sciences, and other sciences.
4. The levels of support available to these disciplines from other sources.

NATIONAL SCIENCE FOUNDATION

RELATIVE INCREASE IN BASIC RESEARCH PROJECT GRANTS SINCE 1960



A-7. In your concluding remarks on June 25, with reference to the NSF Act, you stated:

> ***As we survey the past policies and procedures of the Foundation, however, we recognize several areas in which there exists authorization over and above that which we have fully utilized heretofore. I believe that we can use these additional elements of our authority in ways which are beneficial to the Nation.***

Specifically, what sections of the NSF Act have not been "fully utilized heretofore," and how do you plan to utilize them in the future?

In my earlier remarks quoted in this question I did not say or intend to imply that there were whole sections of the NSF Act which have not been utilized. I had intended to say that, because our mandate is a broad one, there are other things that we can do under it that we have not yet done. Let me give a few examples of the kind of thing I had in mind.

The science development program that we initiated last year is beginning to have a significant impact in the institutions that might be

designated as "fast-rising universities." But there are many institutions of higher education—both 4-year colleges and struggling universities—which need a kind of assistance, a type of financial boost, which is based on criteria different from those used in evaluating science development plan proposals. Thus we need to work hard—and we are doing so—to develop ideas, plans, and programs to help institutions in this category. I like to refer to the still undescribed program we are trying to invent as a "junior science development program." The relevance to the question in this case is: we have the authority to do virtually anything that would help institutions in the category I have mentioned to develop their capabilities for educating students in science or for doing research—but we do not have a specific program directed especially toward helping them solve, institutionally, some of their problems. This is a prime example of where we have and hope to use authorization "over and above that which we have fully utilized heretofore."

We are currently trying to develop a new approach to the matter of assuring substantial, up-to-date education in science for young people planning to become elementary and high school teachers *before* they enter the classrooms where they are to work. This problem of preservice education of teachers is one which we have been concerned about for several years, for it is and has long been clear that we need to find ways of avoiding the present situation under which many of those who enter the teaching profession realize immediately after doing so that their training has been inadequate and, therefore, they have to begin at once (or should do so) to rectify a situation which should not have been allowed to develop. Again, NSF has the authority to cope with this problem: what is needed are the ideas and the funds to attack it in sensible ways. We are looking assiduously for the ideas, and hope to be able to present them (when they have been refined) in an early budget request so that we can get on with the important job of making sure that the young people who enter teaching careers are as well trained as possible when they begin to teach.

Another area is that of encouraging research in problems of current social and economic importance. Given such pressing problems as urbanization and population growth, it is possible, and well within the Foundation's authority, to support more basic research projects directly related to them. Because of the complexity of many of these problems this will, I am sure, require more concerted planning and aggressive leadership than most of our programs in the traditional scientific disciplines. Hence, one of the more effective ways that NSF might contribute to the Federal approach to such broad problems is by supporting studies on the nature of these problems and the types of research activities which can best lead toward their solution.

A-9. Why did the National Science Board recommend that NSF's original coordinating and evaluation functions go to a new group, the Office of Science and Technology?

The National Science Foundation Act of 1950 authorized the Foundation to evaluate scientific research programs undertaken by agencies of the Federal Government, and to correlate the Foundation's scien-

tific research programs with those undertaken by individuals and by public and private research groups; but did not specifically authorize or direct the Foundation to coordinate the programs of other Federal agencies. Thus, while the Foundation clearly had the authority to evaluate the programs of other agencies, it could only have assisted in securing coordination of the programs of other Federal agencies by making recommendations to the President. As the Foundation managed programs of its own, the Board and the Director did not believe that it would be feasible for the Foundation to evaluate or to endeavor to coordinate the work of other agencies while engaging in comparable operations not subject to the evaluation of another body. The Foundation, therefore, at no time attempted to exercise its evaluation function; as noted, it never had any statutory authority to itself coordinate the research activities of other agencies. Accordingly, when the establishment of an Office of Science and Technology was being considered, the National Science Board gave general endorsement to the report of a special Board committee which recommended that a continuing competence be established at a high level, such as in the Executive Office of the President, to coordinate, assess, and evaluate the state and conduct of Federal science and technology.

(See also A–10.)

A–10. How can the NSF assume a more active role in the support of science in view of Reorganization Plan No. 2 which transferred its broad policy functions elsewhere? Does the present law permit such latitude? If so, cite the part of the law which is pertinent.

Reorganization Plan No. 2 of 1962 transferred from the Foundation to the Director of the Office of Science and Technology so much of the policy functions of the Foundation authorized in section 3(a)(1) of the act as would enable him to assist the President in achieving coordinated Federal polices for the promotion of basic research and education in the sciences. In addition, the reorganization plan transferred to the Director of the Office of Science and Technology the function of evaluating scientific research programs undertaken by agencies of the Federal Government as authorized by section 3(a)(6) of the act. As the President made clear at the time, the Foundation is still expected to originate, for the consideration of the President, policy proposals and recommendations concerning the support of basic research and education in the sciences. The Foundation had never been authorized to require other Federal agencies to alter their support of science activities. The transfer of the above responsibilities made no change in the Foundation's authority to itself support scientific activities or in its obligation to strengthen basic research and education in the sciences (sec. 3(b)).

With additional funds, the Foundation could expand its activities in support of basic scientific research and programs to strengthen scientific research potential. Through the authority which it retains to initiate and support programs in the support of basic science (sec. 3(a)(3) of the National Science Foundation Act of 1950) there is ample statutory authority to assume a more active role in the support of science.

(See also A–9.)

A-11. Could copies be made available to the committee of science policy studies conducted by the Foundation in the last few years? What is the current schedule for the completion of such NSF studies now in progress?

The answer to this question is, of course, that all science policy studies conducted by the Foundation can be (and for some time past have been) made available to the committee when published. So can these for which NSF provides support, as in the case of the studies of scientific fields under the auspices of the National Academy of Sciences Committee on Science and Public Policy, when they appear. The Foundation would be happy to forward to the committee any such reports which are not now in its possession.[1]

The Foundation now has underway a series of studies which focus directly upon theoretical and empirical aspects of science policy problems. These are being conducted by members of NSF staff, consultants, and through grants to university research units. They deal with the allocation of Federal support for scientific research, case studies of allocation decisions, the question of priorities for science, the underlying assumptions in science policy planning, and related subjects. It is our hope and expectation that all or most of these studies will lead to findings or analyses that will be of interest to this committee.

Interpreting the term "science policy studies" broadly, I can list the following studies now being conducted by the Foundation, together with the current schedule for the publication of preliminary and final reports:

Title	Estimated date of publication	
	Preliminary report	Final report
Scientists and Engineers in Colleges and Universities, 1961	Issued	August 1965.
High School Backgrounds of Doctorates, 1959-62	None	Do.
Scientist and Engineer Immigration, 1962-63	do	September 1965.
Federal Funds for Research, Development, and Other Scientific Activities, Fiscal Years 1964, 1965, and 1966, vol. XIV.	do	October 1965.
Study of 1964 Graduating Classes	do	Do.
College and University Policies Governing Consulting Activities of Faculty.	do	Do.
Geographic Distribution of Industrial R. & D. Performance Funds, 1962-63.	do	Do.
Education and Training of America's 1960 Scientists and Engineers.	do	Do.
Basic Research, Applied Research, and Development in Industry, 1962.	Issued	November 1965.
America's 1960 Scientists and Engineers: Employment and Other Characteristics, 1960 and 1962.	None	Do.
Graduate Study Patterns of College Graduates	do	Do.
Current and Future Supply of Technicians	do	Do.
The College-Degree Population, 1960	do	Do.
Trends in Immigration of Scientists and Engineers, 1950-64	do	December 1965.
American Science Manpower, 1964	Issued	Do.
American Engineering Manpower, 1964	None	Do.
Employment Patterns of College Graduates	do	January 1966.
Basic Research, Applied Research, and Development in Industry, 1963.	Issued	Do.
Research and Development in Smaller Manufacturing Firms	None	February 1966.
The Recruitment of Academic Scientists	do	March 1966.
Geographic Distribution of Industrial R. & D. Performance Funds, 1964.	do	Do.

[1] We have just reissued a brochure entitled "Publications of the National Science Foundation" which lists all such studies; copies of this brochure have recently been supplied to the committee.

Title	Estimated date of publication	
	Preliminary report	Final report
Followup Study of 1961 Freshmen Classes	None	April 1966.
College and University Policies Governing Support of Graduate Students.	do	Do.
College and University Policies Concerning Nonfaculty Professional Staff.	do	June 1966.
State Government Expenditures for R. & D. Performance, 1964 and 1965.	do	Do.
Scientific Activities of Institutions of Higher Education, 1963–64	December 1965	July 1966.
Basic Research, Applied Research, and Development in Industry, 1964.	October 1965	Do.
Research and Development of Nonprofit Organizations—Expenditures and Manpower, 1964.	March 1966	November 1966.
Characteristics of the Engineering Profession	None	December 1966.
Analysis of Classification of Scientists and Engineers	do	Do.
Characteristics of Science Information Personnel	do	Do.
Estimating Engineering Manpower Needs	do	Do.
Academic and Financial Status of Graduate Students	do	January 1967.

NOTE.—See also A-13, A-14.

A-12. As a former member of the Atomic Energy Commission, whose funds must be authorized annually, do you see any advantage or penalties to this procedure as compared to the continuing authorization now available to the Foundation?

There are many significant differences between the purposes and objectives of the Atomic Energy Commission and those of the National Science Foundation. The act establishing the Atomic Energy Commission predates by only a few years the act establishing the National Science Foundation. In establishing the Atomic Energy Commission, the Congress very wisely perceived the need for specific legislation relating to the development, use, and control of atomic energy. Science had produced a new and awesome energy source which required Government regulation at the highest level.

During the period when I was one of the members of AEC, only the component of the Commission's budget related to major new facilities construction was subject to annual authorization action. In those days, therefore, authorization hearings before the Joint Atomic Energy Committee were not completely parallel to the current situation under which all Commission appropriations are subject to annual authorization. Even so, they did provide important opportunities to exchange information and views with the Congress, particularly in view of the fact that the Commission's involvement with large facilities was then (as it is still) a very significant facet of its entire operation. These appearances to review plans for major facilities usually permitted the members of the committee to explore some problems in reasonable detail. But of at least equal value, in my view, were the numerous special hearings on substantive issues—hearings which explored technical and administratively difficult matters in great depth and with a spirit of genuine mutual interest. During these interchanges, the Commission was able to share ideas with and to learn from the Congress; and, in turn, the Congress was able to develop a fuller appreciation of the agency's programs and problems.

The Congress, in enacting the National Science Foundation Act, recognized the principle that basic science progresses best in an at-

mosphere of free intellectual inquiry. This broad legislation has enabled the Foundation to develop a highly productive relationship with working scientists and academic institutions. Many fine programs have evolved from this cooperation and some of these programs influenced recent Federal aid to education legislation.

Both as a scientist and as a public official concerned with the administration of scientific programs, I naturally would prefer to retain the broad continuing authorities contained in the National Science Foundation Act. Generally, I do not believe that authorizing legislation would materially affect the management of appropriated resources. This committee, like the Joint Committee on Atomic Energy, would, I am sure, give careful consideration to scientific judgments in connection with its consideration of authorizing legislation. The key point in answering your question depends, to a large extent, on the manner in which the Congress would implement such legislation. One of the strong points of the present legislation is the flexibility which is afforded the Foundation in working out the most effective programs with academic institutions and scientists. Annual authorizing legislation in addition to appropriation legislation, potentially at least, has the prospect of curtailing this flexibility—thus leading inevitably to some additional administrative rigidity. The extent of this rigidity is dependent in part upon the nature of the provisions of authorizing legislation. An offsetting factor on the plus side of the question is the fact that hearings on annual authorization legislation would offer an opportunity to discuss Foundation goals and related programs in a broader context than is possible during an appropriation hearing. This would provide a decided benefit by promoting a wider knowledge and improved understanding of the Foundation's programs on the part of a greater number of members of the Congress. I would like to point out here, however, that my experience during the period I served on the Atomic Energy Commission clearly demonstrated that substantive hearings in depth, not directly coupled to the appropriations process, can provide the opportunity for valuable exchange of information and views.

Whatever course of action is adopted by the Congress, I sincerely hope we may have the opportunity of presenting our programs to you in substantive detail and with somewhat greater frequency than heretofore.

A-13. Can you give examples, both before and after the establishment of OST, of the formulation by NSF of science policy guidelines that have been applied across the Government?

A-14. Is there any system, formal or otherwise, of check or follow-through on NFS's reports and recommendations to OST for example, or to other agencies? How are the Foundation's findings generally implemented?

There have been a number of instances in which policies for science, formulated and recommended by the Foundation, have been adopted as Government-wide policy. In addition, of course, there have been many instances in which the Foundation collaborated with other agencies of the Government, including the Bureau of the Budget, OST, the Federal Council for Science and Technology, and agencies which support scientific research, in the development of policy. Among the latter

may be cited, for example, policies pertaining to reimbursement of indirect costs, establishment of fellowship stipends, cost-of-education allowances, etc.

The following are examples of the first type, that of direct policy formulation and recommendation by the Foundation followed by adoption for Government-wide use.

Federal support of "nonsensitive" research.—Early in its operations, the Foundation established its policy relating to support of nonsensitive (unclassified) research not involving considerations of security. Briefly stated, the policy developed was that, in appraising proposals submitted by or on behalf of scientists for support of unclassified research not involving considerations of security, the Foundation would be guided by the judgment of scientists having a working knowledge of the individual's qualifications as to experience, competence, and integrity. However, the Foundation would not knowingly support the work of an avowed Communist or anyone established as being a Communist by judicial proceedings nor that of an individual convicted of sabotage, espionage, sedition, subversive activity under the Smith Act, or a similar crime involving the Nation's security.

This policy was endorsed by the American Association for the Advancement of Science in December 1954. Later, the White House requested the National Academy of Sciences to appoint a special committee to study the problem. In its report to Sherman Adams, assistant to the President, that committee essentially endorsed the Foundation's policy. The assistant to the President responded by indicating that the policy appeared satisfactory to all concerned and stated, in part, "It is noted that these principles are essentially those which support the policy of the National Science Foundation. The departments and agencies will, therefore, follow practices consistent with the recommendations contained in the report of the Academy's Committee." This national policy has remained in force since that time.

East-West exchanges of scientific information.—A Foundation report in 1955 "Preliminary Report on Role of the Federal Government in International Science," National Science Foundation, December 1955) recommended the necessity "to increase the flow of scientific and technical information received from Russia on an exchange basis." As is well known, this concept later became national policy which was formalized in the U.S.A.-U.S.S.R. agreement (the so-called Bronk-Nesmeyanov agreement) of July 9, 1959, for exchange of scientists between the United States and Russia. This agreement has been renewed several times and continues to date.

Government role in research on synthetic rubber.—In December 1955 the Foundation made a series of recommendations ("Recommended Future Role of the Federal Government With Respect to Synthetic Rubber," Report of Special Commission for Rubber Research, National Science Foundation, December 1955) with regard to the Government-sponsored rubber research program which had originally been started as a World War II effort. These recommendations included (*a*) termination of the program, (*b*) substitution of a new program of basic research in related areas, and (*c*) sale of the Government laboratories which were then being used for the synthetic rubber research program.

The Foundation's recommendations were accepted and were fully implemented during calendar year 1956 by administrative and legislative action.

Extension of grant authority to other agencies supporting university research.—On a number of occasions the Foundation recommended that all Federal agencies which support research at institutions of higher education should be authorized to use the grant mechanism, as well as contracts, for support of such research. This recommendation was formally stated in April 1958 ("Government-University Relationships in Federally Sponsored Scientific Research and Development," National Science Foundation, Apr. 1, 1958) as follows:

> It is recommended that, where such authority does not now exist, legislation be sought to authorize Federal agencies, where appropriate, to support scientific research, including facilities and equipment, by means of grants as well as contracts.

This recommendation was enacted into law by the 85th Congress, 2d session, in the form of Public Law 85-934 and was signed by the President on September 6, 1958.

Criteria for support of scientific publications.—A set of criteria for support of scientific publications, journals, monographs, etc., was developed by the Foundation for use in its own programs. These criteria were presented to other Federal agencies and the Federal Council for Science and Technology. They were adopted by the Federal Council on August 1, 1963, and were then disseminated by the Office on Science and Technology as a Federal policy on Federal support of nongovernmental scientific and technical publications.

Strengthening academic capabilities for science throughout the United States.—In a statement presented to the Federal Council's Long Range Planning Committee on May 28, 1964, I reiterated a comment (which I first made to this subcommittee 3 weeks before) concerning the desirability of all agencies of Government seeking out "pockets of strength" wherever they may be located in universities throughout the country and providing support to help develop further the scientific capabilities in such institutions.

I noted that (*a*) helping to develop research potential throughout the Nation is a prime responsibility of the National Science Foundation, but that other agencies must play their part; (*b*) NSF is convinced that additional steps can be taken to assure a wider distribution of research support in academic institutions throughout the country; (*c*) the Foundation, therefore, plans to seek support for a new program designed to attack this matter directly, but it also is determined to reexamine its present evaluation procedures to make sure that they do not have built into them any elements which discriminate against developing institutions. I concluded by saying, "We believe that other agencies might profitably engage in a similar exercise."

Later, I reformulated and particularized these ideas, and submitted them to the Federal Council itself for consideration; these were the ideas embodied in the "four courses of action which should be followed in the effort to optimize academic science and science education throughout the country" to which I referred in my testimony before this body on June 25, 1965.[1] As I mentioned at that time, these sug-

[1] This appeared on pp. 151-154 of the transcript of the hearings.

gestions, modified as a result of FCST discussion, have been adopted in principle by the Federal Council, and plans are going forward to have them enunciated in an appropriate fashion as guidelines for all science-supporting agencies.

The most readily available channel for consideration of NSF recommendations are the committees and panels of the Federal Council for Science and Technology. This mechanism provides a formal means for consideration leading to action on the part of Federal agencies. Although there is no formal system for "checking" on the use made of reports which the Foundation provides to OST or any of the Federal agencies, this does not mean that the Foundation is deprived of knowledge on this score. Such knowledge is obtained in three ways: Through an informal system of continuing communication maintained by staff members of the Foundation with those of other agencies, through the work of interagency committees, and through references made to NSF reports in published and unpublished documents of other agencies which are made available to the Foundation. There are presently no compelling reasons for believing that the cost of creating other procedures and mechanisms for checking on the use made of Foundation reports would be justified.

Findings of the Foundation's varied studies are taken into account in a variety of ways. For example, the work of the President's Science Advisory Committee which led to the recommendations embodied in "Meeting Manpower Needs in Science and Technology" was based in large measure on a number of studies carried out by the Foundation. Special studies and analyses of the manpower situation in the field of oceanography have led to detailed consideration by the Interagency Committee on Oceanography of mechanisms for motivating more students toward training in oceanography and closely related fields.

On a somewhat different plane, Foundation studies of the investment in research and development serve as a widely used body of reference material for all those concerned with making decisions on the future of the scientific enterprise in the United States.

Special staff studies and recommendations for action—on the part of the Foundation itself or other agencies—are prepared from time to time, and the ways in which these documents are dealt with are specific to the nature of the case.

A–15. The point was brought out during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency "x," agency "y," or both. What guidelines or criteria has NSF established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the agency's jurisdiction and, therefore, should, or should not, be supported by the agency? If written criteria have been established, please submit a copy thereof to the committee.

It would not be inappropriate for us to reply to this question in full by saying:

> The NSF Act of 1950 "directs and authorizes" the Foundation to initiate and support basic scientific research * * * in the mathematical, physical, medical, biological, engineering, and other sciences * * *" in a wide variety of ways. Thus,

Congress, in our basic law, established for us the criteria under which we must and do operate in determining whether a project is or is not "within the purview or scope" of our jurisdiction.

Although this is an accurate and (in a sense) complete response, I feel that it would be useful to analyze the implications of this question in some detail.

From a consideration of our statutory authority, it is clear that NSF can support (with a few special exceptions) only *basic* research projects. In our discussion below, therefore, we will be focusing on this area; in effect, this means that we have assumed the word "basic" precedes "research" at each point where the latter is used in question A-15.

The principal guideline that has been established to provide a somewhat more specific delineation of jurisdiction in supporting basic research projects is Executive Order 10521, section 4, which states:

As now or hereafter authorized or permitted by law, the Foundation shall be increasingly responsible for providing support by the Federal Government for general purpose basic research through contracts and grants. The conduct and support by other Federal agencies of basic research in areas which are closely related to their missions is recognized as important and desirable, especially in response to current national needs, and shall continue.[1]

Furthermore, one of the functions of the Federal Council for Science and Technology, which was established by Executive Order 10807, is to—

* * * consider problems and developments in the fields of science and technology and related activities affecting more than one Federal agency or concerning the overall advancement of the Nation's science and technology, and shall recommend policies and other measures (1) to provide more effective planning and administration of Federal scientific and technological programs, (2) to identify research needs including areas of research requiring additional emphasis, (3) to achieve more effective utilization of the scientific and technological resources and facilities of Federal agencies, including the elimination of unnecessary duplication * * *.[2]

These criteria and mechanisms assist in defining, in general terms, the role that each Federal agency will take with regard to scientific research—particularly basic research. However, in considering the day-to-day determinations that must be made in the administration of research programs, it is important to bear in mind that each proposal is an individual case and each has its own special characteristics and dimensions which may or may not be appropriate to the emphases and goals of a particular agency. These considerations continually guide agency administrators in assessing how or where a particular project might best be reviewed and (possibly) funded.

When the Foundation receives a proposal that might be of greater interest or be more appropriate to another agency, such as the Office of Naval Research or the Atomic Energy Commission, the Foundation staff normally checks to see whether the proposal has been submitted to that agency. Conversely, the program officers of mission-oriented agencies frequently suggest that basic research proposals submitted to them be sent also (or instead) to NSF. Section 4 of Executive Order 10521 (quoted above) is obviously an important guid-

[1] Mar. 17, 1954.
[2] Mar. 13, 1959. This Executive Order 10807 amended Executive Order 10521 in part, but did not change sec. 4 (quoted above).

ing statement in such cases. When a proposal is submitted both to NSF and to another possible sponsor, the coordinating mechanisms dealt with in our response to question B–14 are of major importance in the further handling of the matter. Jurisdictional disputes are very rare since there are more meritorious projects to be supported than the combined funds of all the agencies can take care of.

The above discussion deals with general unsolicited proposals for basic research. A notable exception is the case of proposed Antarctic research projects, where the determination of agency responsibility has been made clear through Bureau of the Budget Circular A–51, dated August 3, 1960. Section 4.b. of this circular states:

> Federal agencies interested in scientific activities for Antarctica, either to be conducted by their own staffs or by other agencies and personnel, should inform the National Science Foundation of their interest and of the content of proposed scientific activities that might be included in the U.S. scientific program to be developed and funded by the Foundation. (See also the response to question F–8.)

All proposals regarding Antarctic research received by other agencies are, therefore, immediately referred to the National Science Foundation.

As noted at the beginning of this response, within the National Science Foundation the basic guideline used by all personnel to determine whether a proposal falls within the Foundation's purview is our basic act, Public Law 507, 81st Congress, as amended. This act constitutes the fundamental body of policy which guides all actions. Various subsidiary "interpretative" actions are of course necessary. (See A–19 for an example.)

For practical purposes, guidelines for basic research support are summarized in the booklet "Grants for Scientific Research," which is issued both to guide scientists who are interested in submitting proposals to the Foundation and to provide a "frame of reference" for our own staff. This booklet can be viewed as a summary in operationally useful language of many policy decisions, since it defines the areas supported and discusses ground rules for different classes of applicants; the following relevant excerpts from it may be useful:

TYPES OF BASIC RESEARCH SUPPORTED

> The National Science Foundation will entertain proposals for support of basic research in science. The fields of science supported include but are not limited to: astronomy; atmospheric sciences, including weather modification; biological and medical sciences, including developmental, environmental, genetic, metabolic, molecular, regulatory, and systematic biology, also psychobiology and biological oceanography; chemistry; earth sciences, including physical oceanography; engineering sciences, including chemical, civil, electrical, and mechanical engineering, metallurgy, engineering mechanics, and associated interdisciplinary activities; mathematical sciences; physics; and social sciences, including anthropology, archeology, social psychology, sociology, economics, demography, linguistics, economic and social geography, and the history and philosophy of science.[1]
>
> Foundation support of basic research is given not only to specific projects, but also to programs covering a coherent area of science. Support for graduate thesis research may be included in proposals of either type * * *.

[1] Since the latest version of the booklet was printed, we have announced that political science is now explicitly included also.

WHO MAY SUBMIT

The Foundation considers all requests for support of basic research, regardless of source. Normally, proposals are initiated by the scientist interested in doing the work, and in most instances a formal proposal is submitted on his behalf by his organization. The proposal may, prior to formal submission, be the subject of informal discussions between the scientist and the Foundation staff, either by letter or in person, but this is not required. Graduate students are not encouraged to submit proposals for support of research; instead, they should normally apply either for fellowship support or arrange to serve as research assistants to faculty members holding grants.

Proposals are submitted by five different categories of applicants.

(1) Colleges and universities: The great majority of proposals received by the Foundation are submitted by U.S. universities and colleges on behalf of their staff members * * *.

(2) Nonprofit research institutions: The Foundation's present policy is to emphasize support of research which also contributes to graduate and postdoctoral education in the sciences. Hence, grants will normally be made to nonprofit institutions only when they can demonstrate a close relationship to such education. However, special consideration will be given when the proposed research is judged to be of exceptional significance or where the institution has unique capabilities * * *.

(3) Private profit organizations: The Foundation does not normally give support to basic research performed in private profit organizations. However, under exceptional circumstances support may be considered if one or more of the following criteria are met: (*a*) The research is of special concern from a national point of view and shows unique promise of solving an outstanding scientific problem; (*b*) unique resources are available for the work; or (*c*) the research is of outstanding excellence and will make significant contributions to the training of scientists. Such support is accomplished through the execution of an appropriate form of nonprofit contract rather than by grant.

(4) Foreign institutions: The Foundation provides a limited amount of support to foreign institutions for the conduct of basic research when such action is consistent with the Foundation's responsibilities and objectives * * *.

(5) Individual scientists in the United States: Under special circumstances grants may be made to individual scientists. Before a formal proposal is submitted it is suggested that preliminary inquiry be made to the Foundation.

(See also B-14-E-8; C-4; F-8.)

A-16. We are learning by experience and technical study that land drainage is in truth a science, involving much more than hydrology and soil mechanics—such as, for example, in agricultural areas the chemistry of soils under the influence of fertilizers and pesticides, and the complex reactions which rainfall or irrigation runoff from the land produce in our rivers and bays; and, of course, in urban areas the resulting problems of water pollution by detergents, sewage, and industrial waste. The question is, Do you consider such research within the purview of the National Science Foundation? If so, will you venture into this field at all?

Any proposal for the support of basic research can be submitted for consideration by the Foundation. Therefore, we have supported projects that relate to hydrology, soil mechanics, stream erosion, chemistry of natural waters, biological problems associated with land drainage, etc. Because water resources and land drainage are interdisciplinary in character these proposal are handled in a number of our program offices, e.g., chemistry, engineering, earth sciences, environmental biology, etc.

Many of the types of problems listed in the question fall within the purview of the Public Health Service or the Agricultural Research Service. In addition the recently established Office of Water Resources Research in the Department of Interior also sponsors research in water

resources. All of these agencies are represented on the Committee on Water Resources Research, FCST, and the development of the national program and coordination to avoid duplication is accomplished through the Committee. The Committee is acutely aware of the need for a broader and more cohesive approach to the planning and management of water resources. Indeed, the Committee is currently drafting a recommended long-range program in this field. It seems wise to await the recommended long-range plan before deciding what further step should be taken in the field of water resources. For the present the Foundation plans to continue supporting good proposals in this field, but has no plans to set up a special office dealing with this subject.

A–17. How does the Foundation encourage the acceleration of those areas of science for which it believes growth is needed in the national interest?

When an area of science has been identified by the Foundation as being in need of accelerated growth, the Foundation first attempts to ascertain the nature and extent of the need. This assessment may be done through our own efforts, through consultations with the appropriate advisory committees of the Foundation, or through advisory groups which may be convened by the National Academy of Sciences or other qualified scientific organizations. When the extent of the need has been established, a determination is made as to whether the expanded effort can be accomplished through increased support of scientists already trained in the research area in question and at the institutions where they are located at the time. If this is not the case, it may be decided that scientists from related areas of research should be encouraged to turn their attention to one that needs encouragement, and new organizations created for the purpose of managing the research. The attached memorandum to the Foundation staff provides details on these procedures.

The area of systematic biology provides an excellent example of Foundation encouragement of neglected science areas. When, early in its existence, the Foundation examined the areas of biology which needed special assistance, it determined to establish a systematic biology program as means of providing special support. More recently it became apparent that rising costs and space shortages had caused many universities to donate their systematic research collections to museums. Furthermore, major natural history museums, all nonacademic, were beginning to bear a heavy burden in supporting these collections, and graduate students, for lack of support, were inhibited from using them. The Foundation therefore started to foster cooperative arrangements between these nonacademic museums and nearby universities such that interested students could pursue their academic research work at, and gain support through, the museums—while still retaining traditional ties and curricular control through their universities.

Some 7 or 8 years ago it was determined that university research in inorganic chemistry was lagging in this country. On the recommendation of the Foundation's Advisory Panel for Chemistry, a separate program was established with responsibility for inorganic and analytical chemistry. In this case, enough trained manpower

51–204—65—vol. II——7

was available at universities so that the desired acceleration of effort could be obtained by providing more support through research grants to these people.

At about the same time, it was decided that the national interest required a marked increase in the basic research effort in the atmospheric sciences. To meet the need, a program for atmospheric sciences was established in the same manner, but it was felt that because of the importance and complexity of this type of research, more people having a broad spectrum of abilities in physics, chemistry, and astronomy should be brought into the effort and that special facilities and laboratories should be provided for their use. In order to accomplish this, the National Center for Atmospheric Research was established at Boulder, Colo.

A fourth example relates to the Gilliland committee report on the needs for engineering manpower. The NSF traineeship program established in fiscal year 1964 for engineers and subsequently expanded to the other sciences, is a direct outgrowth of the deliberations of a panel established to define a national problem.

(See also C-4.)

A-18. Does NSF now assert a higher degree of control of its grants than it did in earlier years? Do grants tend to shorter duration? If so, why?

Through the years the Foundation has taken specific steps to bring about a more systematic control of the fiscal and managerial—as contrasted with the scientific—aspects of its grants. In the early years of the research grants programs only grants that were for unusually large amounts or for unusually complex projects were accompanied by budgets specifying the amounts intended for various cost categories. As appropriations and programs grew larger, the early guidelines which had been promulgated primarily for basic research, but which were also frequently used for science education proposals, were supplemented by more specific suggestions which experience had shown to be desirable in evaluating proposals. This became more important during the period fiscal year 1958 to fiscal year 1960 as the Foundation's appropriations increased and the variety of program activities was expanded. In 1958 certain of the larger science education programs began utilizing budget forms to facilitate administrative review of proposals.

In addition to these suggestions regarding the development of proposals, the Foundation systematically prepared guidelines for the administration of specific aspects of projects by grantees, particularly in science education. These evolved from meetings of university representatives, science education project directors and Foundation program administrators. One of the earliest meetings of this nature was held in 1955. From this early start has grown a series of published guides for project directors which cover all major aspects of the financial and administrative "understandings" that relate to NSF grants in the area of science education, and the fellowship and traineeship programs.

As early as fiscal year 1957, letters notifying institutions of the award of grants in certain Foundation programs were routinely accompanied by a detailed budget specifying the grant amounts intended

for various cost categories, such as salaries, equipment, supplies, stipends, travel, and the like. Early in 1963 a decision was made to include such specific budgetary information with all Foundation grant notifications. In fiscal year 1966 a study will be initiated to attempt to determine whether or not our present practices introduce too great a rigidity, especially in research grants.

The Foundation has found it particularly essential to adopt systematic administrative controls with respect to its grants for the construction of facilities. It is now the practice to review final working drawings to determine specifically what is to be constructed with Foundation support. Where two or more Federal agencies join in the support of a new facility, it is now incumbent upon the institution to delineate those components of the facility which are to be supported by each. The Foundation established an architectural unit in fiscal year 1964 to serve both the institutions and the Foundation in these matters.

Because of limitations on the availability of funds, grant durations for support of some basic research areas, notably in the mathematical and physical sciences, have declined during the last 4 years from an average of more than 2 years to less than 1¾ years. During this period, the funds available in the Foundation for the support of research remained nearly constant, while the number of investigators (particularly young ones) meriting support continued to increase. At the same time the cost of research per investigator also increased. In order to provide support for additional investigators during this period, some funds which would ordinarily have been used to provide longer grant durations were used instead for support of new investigators. Nearly all projects for education in the sciences have been funded for only 1 year at a time, and therefore the average duration of this type of grant has not significantly changed. This decline in the average duration of grants is inconsistent with the longer-range nature of basic research activities, and increased the administrative costs involved in reviews and renewal of support for activities which would normally be funded over longer periods. The Foundation is seriously concerned about this and is seeking means to reverse the trend. We are currently developing plans for instituting a type of "continuing grant" which, by means of a letter of intent will assure continued support (for periods up to 5 years) for outstanding basic research investigations with a minimum of administrative review. By means of such "continuing grants"—typically involving an initial award for 2 years, followed by annual extensions—leading scientists would be given commitments by NSF of longer-term support for their studies (provided that funds are available), even though funds would rarely be committed for more than 2 years at any one time.

A-19. How can you support basic research in engineering? Doesn't the term "engineering" by definition run counter to basic research? What is NSF's policy in this regard?

Under section 3(a) (2) of Public Law 507, 81st Congress, the Foundation is authorized and directed—

> To initiate and support basic scientific research and programs to strengthen scientific research potential in the mathematical, physical, medical, biological, engineering, and other sciences, by making contracts or other arrangements (including grants, loans, and other forms of assistance) to support such scien-

tific activities and to appraise the impact of research upon industrial development and upon the general welfare; * * *

Thus, support of the "engineering sciences" is specifically authorized by statute. The accepted engineering sciences include, for example, mechanics of fluids and solids, thermodynamics, transfer processes, electrical theory, and the nature and properties of materials. (More lengthy definitions can be found, for example, in the Journal of Engineering Education, vol. 45, No. 1, pp. 37–91.)

In order to clarify still further the Foundation's operating definition of basic research in engineering, the National Science Board on May 15, 1962, adopted the following resolution:

***Resolved,* That the National Science Board considers that intellectual pursuits at educational institutions intended to advance significantly the basic engineering capabilities of the country are eligible for support by the National Science Foundation as basic research in the engineering services. Such work must be of a true scientific nature and not routine engineering practice, and must meet the usual NSF standards of originality and excellence.**

This definition includes types of research and engineering such as:

(*a*) The development of principles and techniques in a systems engineering design;

(*b*) The development of principles and a philosophy for creative engineering;

(*c*) Interdisciplinary research related to such matters as biomedical engineering, transportation, urban planning, fire prevention, etc.;

(*d*) The principles of generation and control of energy systems and information systems;

(*e*) Analysis and synthesis of processes and systems which contribute to mastery of the environment.

As always, the merit and importance of the proposed research continue to be essential factors for favorable action.

A–20. Are there fields of basic engineering in which the Foundation might play a much larger role than in the past? Can you envision NSF research grants to study such problems as the functioning of columns, rotating machinery, and energy transmission by fluids? How about long-distance energy transmission by extra high voltage electric powerlines? Would the Foundation support technoeconomic research of the national problem of intermodal transportation?

There are areas of basic engineering for which grant support could be increased, within the quality criteria now employed. Grants to study such problems as the functioning of columns and energy transmission by fluids have been made. The following examples are listed from grants made in fiscal years 1963 and 1964:

I. Functioning of columns

1. "Stability of Compression Members," Nicolaas Willems, University of Kansas, GP–3064.

2. "Dynamic Stability of Beam Columns With a Fixed Distance Between Supports," Nicholas F. Morris, New York University, GP–2245.

3. "Stability of Columns and Plates Subject to Time Dependent Loads," Ross M. Evan-Iwanowski, Syracuse University, GP–840.
4. "Experimental Postbuckling of Elastic Plates," C. H. Chang, University of Alabama, GP–551.
5. "Stress Distribution in Prestressed Members," Joseph H. Moore, Clemson University, GP–347.

II. Energy transmission by fluids

1. "Heat Transfer to Non-Newtonian Fluids," B. Goodwin, Northwestern University, GP–3007.
2. "Thermal Conductivities of Fluids," R. Graff, New York City College, GP–3129.
3. "Magneto-Fluid Dynamics," H. Ahlstrom, University of Washington, GP–3065.
4. "Fundamental Studies in Viscous Flow," S. Kline and W. Reynolds, Stanford University, GP–2720.
5. "Turbulent Jet Mixing Considering Effects of Initial Boundary Layer," Morris E. Childs, University of Washington, GP–2038.

The extra high voltage power transmission problem is not now the subject of a grant, but suitable proposals in this area could be considered, subject to the usual criteria for research quality. As for technoeconomic research of the national problem of intermodal transportation, NSF could support high quality university-type research on selected aspects of the transportation problem, but it obviously could not at present support a major applied or developmental effort on this subject. NSF could probably support (and indeed is currently considering the initiation of) a study designed to provide a better understanding of present (and probable future) technical and economic characteristics of national and regional transportation systems involving all modes of transport as a possible framework for applied research supported and carried out by other organizations and of basic research in universities, to be supported, in part, by the Foundation.

A–21. Would you please provide data on the geographical distribution of all the applications for support which the Foundation receives; that is, for fellowships, traineeships, research grants, and institutional grants, in each of the following categories: (1) Those requests which are found to be not qualified for support; (2) those requests which are qualified, but are not supported because of insufficient money; and (3) those requests which are qualified and supported. This information is desired in terms of numbers and dollars for the past 3 years, if possible.

The attached tables include information on the geographic distribution of grants and declinations for fiscal years 1963, 1964, and 1965. Declinations have not been allocated to categories (1) and (2) of the request since data have not been recorded in this precise form in the data processing center. Our experience indicates that only a minor percentage of the proposals we consider could be judged to be completely without merit and, therefore, would not have been eligible for some support had sufficient funds been available.

Tables are included for (*a*) fellowships; (*b*) traineeships;[1] (*c*) science education support (exclusive of fellowships);[2] and (*d*) basic research project support grants. It should be noted that the tables for the first two categories differ from the second two categories in one minor respect: for fellowships and traineeships we show awards as contrasted with all *applications;* for the science education and basic research projects grants, we show awards as contrasted with *declinations.* Institutional grants are a special case since these grants are awarded by formula to all schools that are eligible and that request the institutional base grant; thus the group of applicants is limited—and the group receiving grants is the same group, since there are no declinations. A table showing the distribution of these grants by States for fiscal years 1961–65 is included. Tables have been provided on the distribution of graduate science facilities, including construction and renovation of research and graduate level instructional laboratories. Only 10 grants have been announced in the science development program, another special purpose program for institutional support. A table showing the geographic distribution of these grants is also included. Since final decisions are still pending on most of the proposals received in this program, no analysis of declinations is currently possible.

Tables have not been provided on the geographic distribution of grants and declinations for national research programs, specialized research facilities support, national research centers, and science information services because of the specialized nature of these activities.

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[1] Data on traineeships for fiscal year 1964 (the program's first year) and for fiscal year 1965.

[2] The data on traineeships, shown separately in (b) as indicated, are also included in the tables headed "Science Education Programs."

BASIC RESEARCH PROJECT GRANTS, FISCAL YEARS 1963, 1964, AND 1965

Geographic distribution of grants and proposals, fiscal year 1963

[Dollars in thousands]

State	Grants			Declinations	
	Number	Amount requested	Amount granted	Number	Amount requested
Alabama	5	$323	$106	8	$250
Alaska	8	359	289	4	66
Arizona	21	1,592	714	27	1,758
Arkansas	7	262	164	8	383
California	332	27,711	13,938	130	7,948
Colorado	40	2,353	1,440	38	2,208
Connecticut	80	5,209	3,112	25	1,460
Delaware	10	338	241	4	155
Florida	56	4,159	2,099	33	1,559
Georgia	21	876	550	22	851
Hawaii	17	1,162	578	14	960
Idaho	7	182	146	10	562
Illinois	151	19,340	8,515	92	6,574
Indiana	81	6,445	3,387	52	2,208
Iowa	23	1,115	817	24	977
Kansas	38	1,691	1,030	36	1,422
Kentucky	13	784	453	16	1,077
Louisiana	35	2,244	908	29	1,653
Maine	4	123	49	9	664
Maryland	53	4,446	2,132	10	608
Massachusetts	176	25,433	10,970	74	3,871
Michigan	120	9,626	4,388	85	3,973
Minnesota	49	4,107	1,947	22	803
Mississippi	5	158	88	11	599
Missouri	47	3,777	1,560	32	1,612
Montana	7	195	131	8	184
Nebraska	13	502	444	6	434
Nevada	2	76	29	4	120
New Hampshire	20	1,083	568	10	550
New Jersey	62	4,131	2,790	44	2,687
New Mexico	12	679	292	13	533
New York	282	26,319	11,600	190	15,662
North Carolina	50	2,531	1,595	28	1,424
North Dakota	4	92	78	7	250
Ohio	78	5,651	2,782	81	5,089
Oklahoma	27	1,255	684	25	996
Oregon	45	2,231	1,306	24	949
Pennsylvania	130	9,523	5,655	106	6,072
Rhode Island	21	2,430	906	5	282
South Carolina	9	289	180	13	377
South Dakota	2	58	42	2	67
Tennessee	17	851	512	15	515
Texas	71	4,358	2,167	59	3,181
Utah	26	1,352	668	22	881
Vermont	7	275	160	7	304
Virginia	21	882	454	17	581
Washington	53	4,306	2,178	45	1,944
West Virginia	7	281	198	10	475
Wisconsin	55	5,971	2,794	24	1,030
Wyoming	2	148	65	6	231
District of Columbia	20	1,027	535	20	756
Puerto Rico				5	197
Total	2,442	200,311	98,434	1,611	89,963

Geographic distribution of grants and proposals, fiscal year 1963—Continued

[Percentage distribution]

State	Funds granted as percentage of funds requested	Percentage of total	
		Amount requested	Amount granted
Alabama	18.5	0.2	0.1
Alaska	68.0	.2	.3
Arizona	21.3	1.2	.7
Arkansas	25.4	.2	.2
California	39.1	12.3	14.2
Colorado	31.6	1.6	1.5
Connecticut	46.7	2.3	3.2
Delaware	48.9	.2	.2
Florida	36.7	2.0	2.1
Georgia	31.8	.6	.6
Hawaii	27.2	.7	.6
Idaho	19.6	.3	.2
Illinois	32.9	8.9	8.7
Indiana	39.2	3.0	3.4
Iowa	39.1	.7	.8
Kansas	33.1	1.1	1.1
Kentucky	24.3	.6	.5
Louisiana	23.3	1.3	.9
Maine	6.2	.3	.1
Maryland	42.2	1.7	2.2
Massachusetts	37.4	10.1	11.1
Michigan	32.3	4.7	4.5
Minnesota	39.7	1.7	2.0
Mississippi	11.6	.3	.1
Missouri	28.9	1.9	1.6
Montana	34.6	.1	.1
Nebraska	47.4	.3	.5
Nevada	14.8	.1	(1)
New Hampshire	34.8	.6	.6
New Jersey	40.9	2.4	2.8
New Mexico	24.1	.4	(1)
New York	27.6	14.5	11.8
North Carolina	40.3	1.4	1.6
North Dakota	22.6	.1	.1
Ohio	25.9	3.7	2.8
Oklahoma	30.3	.8	.7
Oregon	41.1	1.1	1.3
Pennsylvania	36.3	5.4	5.7
Rhode Island	33.3	.9	.9
South Carolina	27.2	.2	.2
South Dakota	33.6	(1)	(1)
Tennessee	37.5	.5	.5
Texas	28.7	2.6	2.2
Utah	60.5	.8	.7
Vermont	27.6	.2	.2
Virginia	31.0	.5	.5
Washington	34.8	2.2	2.2
West Virginia	26.2	.3	.2
Wisconsin	39.9	2.4	2.8
Wyoming	17.2	.1	.1
District of Columbia	30.0	.6	.5
Puerto Rico	------------	.1	------------
Total	33.9	100.0	100.0

[1] Less than 0.05 percent.

NOTE.—Detail may not add to total because of rounding.

Geographic distribution of grants and proposals, fiscal year 1964

BASIC RESEARCH PROJECT GRANTS

[Dollars in thousands]

State	Grants			Declinations	
	Number	Amount requested	Amount granted	Number	Amount requested
Alabama	5	$233	$109	11	$766
Alaska	13	559	444	7	324
Arizona	37	1,871	1,219	31	1,747
Arkansas	9	490	275	9	403
California	370	40,929	16,708	160	9,548
Colorado	34	2,418	1,290	29	1,273
Connecticut	78	6,875	3,203	28	1,587
Delaware	10	379	273	6	158
Florida	68	6,048	2,644	44	2,608
Georgia	26	1,386	713	24	1,627
Hawaii	22	1,260	841	23	1,043
Idaho	5	103	74	4	83
Illinois	177	18,230	9,301	101	5,320
Indiana	66	7,867	2,554	53	4,654
Iowa	40	3,119	1,533	22	894
Kansas	34	1,781	889	36	1,678
Kentucky	16	682	325	16	649
Louisiana	25	2,252	916	27	1,099
Maine	6	141	120	4	244
Maryland	47	5,658	2,315	14	766
Massachusetts	187	23,904	10,420	67	4,781
Michigan	99	7,760	3,739	88	4,451
Minnesota	49	5,425	1,781	30	2,200
Mississippi	2	80	65	10	396
Missouri	41	3,424	1,521	31	2,280
Montana	13	437	279	10	364
Nebraska	6	248	144	8	439
Nevada	4	200	177	2	113
New Hampshire	28	1,585	796	20	909
New Jersey	51	6,493	2,867	45	2,669
New Mexico	19	1,615	490	25	1,027
New York	246	33,195	10,550	191	12,364
North Carolina	63	4,401	2,541	34	2,071
North Dakota	4	133	81	10	555
Ohio	69	5,899	2,094	85	6,078
Oklahoma	17	767	411	37	2,420
Oregon	64	4,663	2,268	30	1,402
Pennsylvania	140	11,765	5,296	95	5,611
Rhode Island	31	2,066	1,148	14	756
South Carolina	8	237	118	9	417
South Dakota	5	203	92	6	163
Tennessee	28	1,595	819	27	1,895
Texas	75	4,250	2,431	86	4,844
Utah	30	1,390	781	25	1,543
Vermont	5	216	118	1	21
Virginia	20	1,461	494	26	894
Washington	61	5,343	2,693	43	2,116
West Virginia	6	172	97	9	290
Wisconsin	79	11,958	3,962	37	1,577
Wyoming	3	65	40	6	308
District of Columbia	20	1,326	482	21	961
Total	2,561	244,546	104,541	1,777	102,386

Geographic distribution of grants and proposals, fiscal year 1964—Continued

[Percentage distribution]

State	Funds granted as percentage of funds requested	Percentage of total	
		Amount requested	Amount granted
Alabama	10.9	0.3	0.1
Alaska	50.3	.3	.4
Arizona	33.7	1.0	1.2
Arkansas	30.8	.3	.3
California	33.1	14.6	16.0
Colorado	35.0	1.1	1.2
Connecticut	37.9	2.4	3.1
Delaware	50.8	.2	.3
Florida	30.6	2.5	2.5
Georgia	23.7	.9	.7
Hawaii	36.5	.7	.8
Idaho	39.8	.5	.1
Illinois	39.5	6.8	8.9
Indiana	20.4	3.6	2.4
Iowa	38.2	1.2	1.5
Kansas	25.7	1.0	.9
Kentucky	24.4	.4	.3
Louisiana	27.3	1.0	.9
Maine	31.2	.1	.1
Maryland	36.0	1.9	.2
Massachusetts	36.3	8.3	10.0
Michigan	30.6	3.5	3.6
Minnesota	23.4	2.2	1.7
Mississippi	13.7	.1	.1
Missouri	26.7	1.6	1.5
Montana	34.8	.2	.3
Nebraska	21.0	.2	.1
Nevada	56.5	.1	.2
New Hampshire	31.9	.7	.8
New Jersey	31.3	2.6	2.7
New Mexico	18.6	.8	.5
New York	23.2	13.1	10.1
North Carolina	39.3	1.9	2.4
North Dakota	11.8	.2	.1
Ohio	17.5	3.5	2.0
Oklahoma	12.9	.9	.4
Oregon	37.4	1.8	2.2
Pennsylvania	30.5	5.0	5.1
Rhode Island	40.7	.8	1.1
South Carolina	18.0	.2	.1
South Dakota	25.1	.1	.1
Tennessee	23.5	1.0	.8
Texas	26.7	2.6	2.3
Utah	26.6	.9	.8
Vermont	49.8	.1	.1
Virginia	21.0	.7	.5
Washington	36.1	2.2	2.6
West Virginia	21.0	.1	.1
Wisconsin	29.3	3.9	3.8
Wyoming	10.7	.1	(1)
District of Columbia	21.1	.7	.5
Puerto Rico			
Total	30.1	100.0	100.0

[1] Less than 0.05 percent.

NOTE.—Detail may not add to total because of rounding.

Geographic distribution of grants and proposals, fiscal year 1965

BASIC RESEARCH PROJECT GRANTS

[Dollars in thousands]

State	Grants			Declinations	
	Number	Amount requested	Amount granted	Number	Amount requested
Alabama	6	$444	$180	12	$455
Alaska	16	993	899	9	794
Arizona	43	3,193	1,554	38	1,759
Arkansas	9	491	224	18	468
California	420	37,503	18,601	147	8,782
Colorado	51	3,368	1,813	46	2,311
Connecticut	81	5,244	2,928	18	781
Delaware	11	496	228	6	192
Florida	85	4,904	2,522	63	3,591
Georgia	40	1,780	965	39	1,917
Hawaii	30	2,692	1,280	19	1,272
Idaho	6	170	87	8	528
Illinois	188	19,978	8,266	106	6,266
Indiana	114	10,140	4,494	47	2,637
Iowa	28	1,174	723	24	1,299
Kansas	55	3,087	1,370	36	1,233
Kentucky	22	1,720	738	20	1,149
Louisiana	23	1,630	584	25	1,094
Maine	4	178	44	3	116
Maryland	52	5,014	2,110	24	1,658
Massachusetts	221	24,950	12,239	76	7,041
Michigan	132	10,329	5,228	77	4,257
Minnesota	54	4,824	2,208	26	1,681
Mississippi	3	337	103	7	378
Missouri	44	3,986	1,825	49	1,980
Montana	14	497	298	11	290
Nebraska	14	761	352	8	496
Nevada	5	632	299	3	156
New Hampshire	25	1,126	655	16	834
New Jersey	85	10,122	4,749	47	2,119
New Mexico	25	1,938	890	16	685
New York	339	30,331	15,585	203	12,231
North Carolina	49	2,623	1,823	31	1,532
North Dakota	3	153	60	4	90
Ohio	115	7,161	3,310	72	3,994
Oklahoma	28	1,108	715	38	1,507
Oregon	67	3,544	2,178	20	658
Pennsylvania	185	13,707	7,225	116	5,840
Rhode Island	46	4,609	1,613	21	867
South Carolina	11	360	230	17	609
South Dakota	4	94	63	8	232
Tennessee	24	1,313	588	23	1,176
Texas	95	4,764	2,645	73	4,238
Utah	41	2,586	1,165	23	1,188
Vermont	5	343	87	6	184
Virginia	31	1,318	756	42	1,537
Washington	81	6,407	2,611	32	1,256
West Virginia	8	449	254	4	98
Wisconsin	93	7,694	3,867	47	2,137
Wyoming	5	181	150	6	278
District of Columbia	26	1,403	653	29	1,042
Total	3,162	253,789	124,034	1,859	98,802

Geographic distribution of grants and proposals, fiscal year 1965—Continued

[Percentage distribution]

State	Funds granted as percentage of funds requested	Percentage of total	
		Amount requested	Amount granted
Alabama	20.0	0.3	0.2
Alaska	50.3	.5	.7
Arizona	31.4	1.4	1.3
Arkansas	23.4	.3	.2
California	40.2	13.1	15.0
Colorado	31.9	1.6	1.5
Connecticut	48.6	1.7	2.4
Delaware	33.1	.2	.2
Florida	29.7	2.4	2.0
Georgia	26.1	1.1	.8
Hawaii	32.3	1.1	1.0
Idaho	12.5	.2	.1
Illinois	31.5	7.4	6.7
Indiana	35.2	3.6	3.6
Iowa	29.2	.7	.6
Kansas	31.7	1.2	1.1
Kentucky	25.7	.8	.6
Louisiana	21.4	.8	.5
Maine	15.0	.1	(1)
Maryland	31.6	1.9	1.7
Massachusetts	38.3	9.1	9.9
Michigan	35.8	4.1	4.2
Minnesota	34.2	1.8	1.8
Mississippi	14.4	.2	.1
Missouri	30.8	1.7	1.5
Montana	37.9	.2	.2
Nebraska	28.0	.4	.3
Nevada	37.9	.2	.2
New Hampshire	33.4	.6	.5
New Jersey	38.8	3.5	3.8
New Mexico	33.9	.7	.7
New York	36.6	12.1	12.6
North Carolina	43.9	1.2	1.5
North Dakota	24.7	.1	.1
Ohio	29.8	3.2	2.7
Oklahoma	27.3	.7	.6
Oregon	51.8	1.2	1.8
Pennsylvania	37.0	5.5	5.8
Rhode Island	29.5	1.6	1.3
South Carolina	23.7	.3	.2
South Dakota	19.3	.1	.1
Tennessee	23.6	.7	.5
Texas	29.4	2.6	2.1
Utah	30.9	1.1	.9
Vermont	16.5	.2	.1
Virginia	26.5	.8	.6
Washington	34.1	2.2	2.1
West Virginia	46.9	.2	.2
Wisconsin	39.3	2.8	3.1
Wyoming	32.7	.1	.1
District of Columbia	26.7	.7	.5
Puerto Rico	----------	----------	----------
Total	35.2	100.0	100.0

[1] Less than 0.05 percent.

NOTE.—Detail may not ecause of rounding.

TRAINEESHIPS, FISCAL YEARS 1964 AND 1965

Geographic distribution of grants and proposals, fiscal year 1964

GRADUATE TRAINEESHIPS IN ENGINEERING [1]

[Distribution of proposals and grants, by State]

State	Proposals			Grants		
	Number	Number of traineeships	Amount	Number	Number of traineeships	Amount
Alabama	2	57	$280,326	2	9	$44,262
Alaska [2]	0	0	0	0	0	0
Arizona	2	94	462,292	2	19	93,442
Arkansas	1	12	59,016	1	3	14,754
California	7	563	2,768,834	7	152	747,536
Colorado	4	103	506,554	4	30	147,540
Connecticut	2	48	236,064	2	14	68,852
Delaware	1	22	108,196	1	9	44,262
District of Columbia	2	40	196,720	2	7	34,426
Florida	1	42	206,556	1	11	54,098
Georgia	1	74	363,932	1	19	93,442
Hawaii [2]	0	0	0	0	0	0
Idaho	1	16	78,688	1	2	9,836
Illinois	3	220	1,081,960	3	95	467,210
Indiana	2	116	570,488	1	60	295,080
Iowa	2	77	378,686	2	19	93,442
Kansas	2	72	354,096	2	13	63,934
Kentucky	1	12	59,016	1	3	14,754
Louisiana	2	33	162,294	2	10	49,180
Maine	1	15	73,770	1	3	14,754
Maryland	2	42	206,556	2	18	88,524
Massachusetts	6	223	1,096,714	6	107	526,266
Michigan	4	212	1,042,616	4	72	354,096
Minnesota	1	76	373,768	1	32	157,376
Mississippi	1	24	118,032	1	2	9,836
Missouri	2	121	595,078	2	22	108,196
Montana	1	20	98,360	1	5	24,590
Nebraska	1	18	88,524	1	2	9,836
Nevada	1	19	93,442	1	2	9,836
New Hampshire	1	5	24,590	1	3	14,754
New Jersey	4	104	511,472	3	31	152,458
New Mexico	2	30	147,540	2	13	63,934
New York	13	411	2,021,298	13	137	673,766
North Carolina	2	44	216,392	2	18	88,524
North Dakota [2]	0	0	0	0	0	0
Ohio	3	178	875,404	3	37	181,966
Oklahoma	2	128	629,504	2	19	93,442
Oregon	1	29	142,622	1	5	24,590
Pennsylvania	5	215	1,057,370	5	65	319,670
Rhode Island	2	32	157,376	2	10	49,180
South Carolina	2	41	201,638	2	7	34,426
South Dakota [2]	0	0	0	0	0	0
Tennessee	2	38	186,884	2	8	39,344
Texas	6	153	752,454	6	45	221,310
Utah	2	53	260,654	2	15	73,770
Vermont [2]	0	0	0	0	0	0
Virginia	2	51	250,818	2	16	78,688
Washington	2	74	363,932	2	24	118,032
West Virginia	1	28	137,704	1	2	9,836
Wisconsin	1	79	388,522	1	23	113,114
Wyoming	1	18	88,524	1	2	9,836
Total	110	4,082	20,075,276	109	1,220	6,000,000

[1] During the 1st year of operation of the NSF graduate traineeship program (fiscal year 1964) awards were limited to the engineering fields, and only institutions awarding the Ph. D. in 1 or more engineering departments were eligible to submit proposals.

[2] No institution in State was eligible to apply (i.e., none had Ph. D. degree granting program in engineering).

Geographic distribution of grants and proposals, fiscal year 1964—Continued

[Percentage distribution by State]

State	Funds granted as percentage of funds requested	Percentage of total	
		Funds requested	Funds granted
Alabama	15.8	1.4	1.3
Alaska			
Arizona	20.2	2.3	1.6
Arkansas	25.0	.3	.2
California	27.0	13.8	12.5
Colorado	29.1	2.5	2.5
Connecticut	29.2	1.2	1.1
Delaware	40.9	.5	.7
District of Columbia	17.5	1.0	.6
Florida	26.2	1.0	.9
Georgia	25.7	1.8	1.6
Hawaii			
Idaho	12.5	.4	.2
Illinois	43.2	5.4	7.8
Indiana	51.7	2.8	4.9
Iowa	24.7	1.9	1.6
Kansas	18.1	1.8	1.1
Kentucky	25.0	.3	.2
Louisiana	30.3	.8	.8
Maine	20.0	.4	.2
Maryland	42.9	1.0	1.5
Massachusetts	48.0	5.5	8.8
Michigan	34.0	5.2	5.9
Minnesota	42.1	1.9	2.6
Mississippi	8.3	.6	.2
Missouri	18.2	3.0	1.8
Montana	25.0	.5	.4
Nebraska	11.1	.4	.2
Nevada	10.5	.5	.2
New Hampshire	60.0	.1	.2
New Jersey	29.8	2.5	2.5
New Mexico	43.3	.7	1.1
New York	33.3	10.1	11.2
North Carolina	40.9	1.1	1.5
North Dakota			
Ohio	20.8	4.4	3.0
Oklahoma	14.8	3.1	1.6
Oregon	17.2	.7	.4
Pennsylvania	30.2	5.3	5.3
Rhode Island	31.3	.8	.8
South Carolina	17.1	1.0	.6
South Dakota			
Tennessee	21.1	.9	.7
Texas	29.4	3.7	3.7
Utah	28.3	1.3	1.2
Vermont			
Virginia	31.4	1.2	1.3
Washington	32.4	1.8	2.0
West Virginia	7.1	.7	.2
Wisconsin	29.1	1.9	1.9
Wyoming	11.1	.4	.2
Total	29.9	[1] 100.0	[1] 100.0

[1] Detail may not add to total because of rounding.

Geographic distribution of grants and proposals, fiscal year 1965

GRADUATE TRAINEESHIPS IN THE ENGINEERING, MATHEMATICAL, AND PHYSICAL SCIENCES (INCLUDING BIOCHEMISTRY AND BIOPHYSICS)

[Distribution of proposals and grants, by State]

State	Proposals			Grants		
	Number	Number of traineeships	Amount	Number	Number of traineeships	Amount
Alabama	4	93	$488,767	4	15	$84,883
Alaska	1	8	41,424	1	2	10,356
Arizona	4	162	851,132	4	45	245,306
Arkansas	2	33	173,024	2	6	33,218
California	18	1,091	5,723,591	17	338	1,824,557
Colorado	8	182	958,063	8	54	295,279
Connecticut	5	178	926,577	5	46	243,081
Delaware	2	44	231,715	2	18	97,087
District of Columbia	6	116	602,589	6	24	126,213
Florida	4	189	986,630	4	48	256,532
Georgia	4	150	787,690	4	45	244,000
Hawaii	1	29	150,162	1	4	20,712
Idaho	2	18	95,686	2	6	33,550
Illinois	9	625	3,274,975	9	190	1,022,545
Indiana	5	313	1,636,057	5	111	610,101
Iowa	4	159	836,449	4	40	220,267
Kansas	4	128	671,566	4	32	174,478
Kentucky	3	55	286,805	3	14	74,507
Louisiana	5	106	557,483	5	30	163,955
Maine	2	31	163,883	2	5	29,255
Maryland	4	121	632,752	4	48	254,758
Massachusetts	17	578	3,042,869	16	200	1,085,585
Michigan	8	416	2,188,876	8	141	764,926
Minnesota	2	165	863,432	2	56	299,030
Mississippi	4	57	297,628	3	9	49,084
Missouri	7	235	1,226,322	6	51	273,570
Montana	3	49	258,399	3	12	66,813
Nebraska	2	38	200,168	2	9	50,006
Nevada	2	22	114,058	2	5	26,032
New Hampshire	3	36	186,871	3	14	72,955
New Jersey	8	232	1,215,887	8	78	418,475
New Mexico	4	75	397,965	4	19	107,997
New York	30	1,094	5,714,562	30	327	1,743,036
North Carolina	6	174	905,858	6	54	284,498
North Dakota	2	58	300,324	2	4	20,712
Ohio	10	355	1,865,857	9	92	504,043
Oklahoma	4	153	803,809	4	28	156,559
Oregon	3	70	367,137	3	20	108,237
Pennsylvania	13	506	2,647,710	13	163	871,656
Rhode Island	5	109	567,636	4	27	143,040
South Carolina	4	60	317,751	4	13	74,385
South Dakota	2	27	139,806	2	5	25,890
Tennessee	4	114	594,554	4	32	169,958
Texas	15	416	2,192,030	15	107	592,028
Utah	5	141	750,474	5	37	211,962
Vermont	1	12	62,136	1	2	10,356
Virginia	5	128	670,856	5	31	168,590
Washington	4	155	825,840	4	54	302,862
West Virginia	2	52	270,388	2	7	37,378
Wisconsin	3	262	1,369,442	3	59	318,308
Wyoming	2	32	167,728	2	7	38,278
Total	277	9,652	50,623,393	271	2,784	15,060,889

Geographic distribution of grants and proposals, fiscal year 1965—Continued

[Percentage distribution by State]

State	Funds granted as percentage of funds requested	Percentage of total	
		Funds requested	Funds granted
Alabama	17.4	1.0	0.6
Alaska	25.0	.1	.1
Arizona	28.8	1.7	1.6
Arkansas	19.2	.3	.2
California	31.9	11.3	12.1
Colorado	30.8	1.9	2.0
Connecticut	26.2	1.8	1.6
Delaware	41.9	.5	.6
District of Columbia	20.9	1.2	.8
Florida	26.0	1.9	1.7
Georgia	31.0	1.6	1.6
Hawaii	13.8	.3	.1
Idaho	35.1	.2	.2
Illinois	31.2	6.5	6.8
Indiana	36.8	3.3	4.1
Iowa	26.3	1.7	1.5
Kansas	26.0	1.3	1.2
Kentucky	26.0	.6	.5
Louisiana	29.4	1.1	1.1
Maine	17.9	.3	.2
Maryland	40.3	1.2	1.7
Massachusetts	35.7	6.0	7.2
Michigan	34.9	4.3	5.1
Minnesota	34.6	1.7	2.0
Mississippi	16.5	.6	.3
Missouri	22.3	2.4	1.8
Montana	25.9	.5	.4
Nebraska	25.0	.4	.3
Nevada	22.8	.2	.2
New Hampshire	39.0	.4	.5
New Jersey	34.4	2.4	2.8
New Mexico	27.1	.8	.7
New York	30.5	11.3	11.6
North Carolina	31.4	1.8	1.9
North Dakota	6.9	.6	.1
Ohio	27.0	3.7	3.3
Oklahoma	19.5	1.6	1.0
Oregon	29.5	.7	.7
Pennsylvania	32.9	5.2	5.8
Rhode Island	24.3	1.1	.9
South Carolina	23.4	.6	.5
South Dakota	18.5	.3	.2
Tennessee	28.6	1.2	1.1
Texas	27.0	4.3	3.9
Utah	28.2	1.5	1.4
Vermont	16.7	.1	.1
Virginia	25.1	1.3	1.1
Washington	36.7	1.6	2.0
West Virginia	13.8	.5	.2
Wisconsin	23.2	2.7	2.1
Wyoming	22.8	.3	.3
Total	29.8	[1] 100.0	[1] 100.0

[1] Detail may not add to total because of rounding.

FELLOWSHIPS, FISCAL YEARS 1963, 1964, AND 1965

Geographic distribution of applicants and awardees, by State of permanent residence, fiscal year 1963

FELLOWSHIPS

State	Number of applicants	Number of awardees	Percent awards to applicants	Estimated cost of awards
Alabama	145	32	22.0	$151,335
Alaska	10	2	20.0	15,732
Arizona	116	31	26.7	136,585
Arkansas	99	14	14.1	87,273
California	1,542	570	36.9	2,480,361
Colorado	228	70	30.7	271,985
Connecticut	241	72	29.8	298,638
Delaware	48	16	33.3	63,768
District of Columbia	108	31	28.7	157,261
Florida	294	81	27.5	321,549
Georgia	187	48	25.6	204,792
Hawaii	32	12	37.5	46,358
Idaho	61	15	24.5	62,736
Illinois	1,014	371	36.5	1,517,441
Indiana	408	143	35.0	615,830
Iowa	257	84	32.6	324,307
Kansas	268	88	32.8	378,216
Kentucky	183	58	31.6	243,882
Louisiana	258	59	22.8	253,231
Maine	64	14	21.8	66,969
Maryland	308	98	31.8	398,455
Massachusetts	587	196	33.3	858,059
Michigan	605	188	31.0	781,418
Minnesota	419	155	36.9	589,363
Mississippi	127	23	18.1	78,865
Missouri	387	115	29.7	426,154
Montana	67	15	22.3	60,582
Nebraska	144	34	23.6	149,574
Nevada	17	4	23.5	20,901
New Hampshire	67	15	22.3	74,832
New Jersey	623	191	30.6	737,455
New Mexico	138	32	23.1	136,746
New York	2,300	723	31.4	2,979,034
North Carolina	252	68	26.9	301,245
North Dakota	85	31	36.4	120,143
Ohio	746	231	30.9	940,002
Oklahoma	222	64	28.8	266,177
Oregon	202	59	29.2	293,507
Pennsylvania	1,018	295	28.9	1,232,896
Rhode Island	87	23	26.4	97,715
South Carolina	119	32	26.8	119,380
South Dakota	65	17	26.1	102,847
Tennessee	244	56	22.9	209,327
Texas	685	177	25.8	704,618
Utah	157	54	34.3	215,447
Vermont	36	12	33.3	63,007
Virginia	274	67	24.4	283,589
Washington	295	100	33.8	423,007
West Virginia	84	24	28.5	111,450
Wisconsin	339	110	32.4	441,349
Wyoming	48	16	33.3	66,822
Puerto Rico	27	3	11.1	18,722
Total	16,337	5,039	30.8	21,000,937

Geographic distribution of applicants and awardees, by State of permanent residence, fiscal year 1964

FELLOWSHIPS

State	Number of applicants	Number of awardees	Percent awards to applicants	Estimated cost of awards
Alabama	151	30	19.9	$137,787
Alaska	16	3	18.8	21,073
Arizona	161	45	28.0	209,158
Arkansas	147	25	17.0	124,125
California	1,837	569	31.0	2,731,000
Colorado	300	64	21.3	339,116
Connecticut	331	102	30.8	502,623
Delaware	73	16	21.9	67,481
District of Columbia	113	33	29.2	146,689
Florida	346	77	22.3	362,405
Georgia	228	59	25.9	261,659
Hawaii	32	10	31.3	62,083
Idaho	84	15	17.9	87,466
Illinois	1,097	320	29.2	1,435,549
Indiana	424	108	25.5	514,967
Iowa	298	82	27.5	393,390
Kansas	308	73	23.7	311,196
Kentucky	184	53	28.8	233,284
Louisiana	217	51	23.5	219,990
Maine	65	19	29.2	73,944
Maryland	401	122	30.4	569,363
Massachusetts	760	206	27.1	977,206
Michigan	754	199	26.9	861,796
Minnesota	451	130	28.8	554,879
Mississippi	139	32	23.0	148,636
Missouri	400	104	26.0	461,977
Montana	108	18	16.7	67,393
Nebraska	134	34	25.4	135,512
Nevada	36	9	25.0	46,046
New Hampshire	83	26	31.3	124,862
New Jersey	745	205	27.5	949,073
New Mexico	134	27	20.1	121,233
New York	2,600	747	28.7	3,341,842
North Carolina	293	69	23.5	334,617
North Dakota	104	24	23.1	91,771
Ohio	897	212	23.6	893,442
Oklahoma	239	57	23.8	244,938
Oregon	214	64	29.9	313,972
Pennsylvania	1,267	331	26.1	1,426,222
Rhode Island	100	28	28.0	139,133
South Carolina	116	26	22.4	128,130
South Dakota	71	19	26.8	84,691
Tennessee	240	59	24.6	290,995
Texas	860	198	23.0	907,679
Utah	201	48	23.9	212,939
Vermont	45	10	22.2	32,015
Virginia	281	59	21.0	297,861
Washington	367	94	25.6	421,197
West Virginia	133	24	18.0	108,108
Wisconsin	446	136	30.5	611,587
Wyoming	52	13	25.0	83,651
Panama Canal Zone	1	0		
Puerto Rico	37	3	8.1	28,251
Total	19,121	5,087	26.6	23,255,000

Geographic distribution of applicants and awardees, by State of permanent residence, fiscal year 1965

FELLOWSHIPS

State	Number of applicants	Number of awardees	Percent awards to applicants	Estimated cost of awards
Alabama	186	33	17.7	$184,811
Alaska	20	7	35.0	50,127
Arizona	157	51	32.5	229,482
Arkansas	115	31	27.0	183,619
California	1,932	583	30.2	2,989,330
Colorado	296	65	22.0	302,240
Connecticut	360	76	21.1	384,568
Delaware	62	18	29.0	107,160
District of Columbia	119	27	22.7	133,155
Florida	366	83	22.7	405,096
Georgia	198	41	20.7	206,952
Hawaii	48	10	20.8	69,268
Idaho	88	20	22.7	99,940
Illinois	1,306	315	24.1	1,516,755
Indiana	453	108	23.8	537,701
Iowa	338	99	29.3	449,156
Kansas	274	71	25.9	325,528
Kentucky	225	57	25.3	287,592
Louisiana	267	54	20.2	266,048
Maine	66	14	21.2	54,319
Maryland	447	118	26.4	579,366
Massachusetts	779	188	24.1	879,582
Michigan	773	220	28.5	1,099,556
Minnesota	482	103	21.4	504,640
Mississippi	167	27	16.2	129,011
Missouri	411	98	23.8	468,755
Montana	142	21	14.8	126,150
Nebraska	128	34	26.6	176,716
Nevada	27	6	22.2	30,055
New Hampshire	84	26	31.0	107,261
New Jersey	814	191	23.5	915,985
New Mexico	133	28	21.0	140,907
New York	2,987	741	24.8	3,582,071
North Carolina	292	68	23.3	323,865
North Dakota	107	20	18.7	100,097
Ohio	898	227	25.3	1,066,682
Oklahoma	270	48	17.8	238,784
Oregon	244	61	25.0	338,503
Pennsylvania	1,359	293	21.6	1,419,120
Rhode Island	125	28	22.4	97,326
South Carolina	126	23	18.3	106,882
South Dakota	83	18	21.7	113,986
Tennessee	282	51	18.1	282,644
Texas	835	200	24.0	949,579
Utah	170	43	25.3	211,464
Vermont	55	11	20.0	64,853
Virginia	301	74	24.6	413,711
Washington	406	88	21.7	411,555
West Virginia	145	31	21.4	150,485
Wisconsin	504	132	26.2	615,833
Wyoming	63	10	15.9	59,242
Puerto Rico	22	3	13.6	15,090
Total	20,539	4,993	24.3	24,502,603

SCIENCE EDUCATION PROGRAMS, FISCAL YEARS 1963, 1964, AND 1965

Geographic distribution of grants and proposals, fiscal year 1963

SCIENCE EDUCATION PROGRAMS (EXCLUDES FELLOWSHIPS)

[Dollars in thousands]

State	Grants			Declinations	
	Number	Amount requested	Amount granted	Number	Amount requested
Alabama	28	$751	$735	25	$580
Alaska	2	92	89	1	34
Arizona	34	1,199	1,095	11	325
Arkansas	19	382	372	16	257
California	161	8,472	6,235	98	3,495
Colorado	55	5,191	3,699	47	1,312
Connecticut	39	919	834	17	651
Delaware	9	166	127	7	143
Florida	49	1,560	1,211	30	716
Georgia	39	1,473	1,364	31	588
Hawaii	18	476	455	3	31
Idaho	8	296	269	5	99
Illinois	106	5,143	3,831	60	1,799
Indiana	86	2,528	2,427	44	837
Iowa	55	1,622	1,404	28	739
Kansas	49	1,682	1,506	44	1,278
Kentucky	23	544	516	28	431
Louisiana	61	1,581	1,361	62	1,578
Maine	19	607	532	10	279
Maryland	32	805	569	12	318
Massachusetts	145	6,985	5,940	50	3,779
Michigan	101	3,250	2,778	60	1,849
Minnesota	63	1,620	1,593	24	775
Mississippi	24	927	744	24	586
Missouri	57	1,921	1,745	43	1,004
Montana	18	420	387	12	290
Nebraska	17	416	412	6	59
Nevada	6	109	114	2	69
New Hampshire	22	561	433	7	62
New Jersey	81	2,416	1,690	36	621
New Mexico	32	1,326	1,246	26	624
New York	256	10,485	7,460	121	2,882
North Carolina	77	2,848	2,340	45	1,080
North Dakota	33	819	712	18	203
Ohio	120	3,695	3,190	70	1,461
Oklahoma	63	2,299	1,897	41	2,743
Oregon	46	1,658	1,406	24	526
Pennsylvania	164	3,808	3,345	89	3,632
Rhode Island	26	753	740	4	79
South Carolina	13	504	483	19	476
South Dakota	22	781	760	11	242
Tennessee	71	1,930	1,620	49	1,219
Texas	112	3,032	2,671	89	2,155
Utah	21	846	832	10	140
Vermont	10	250	231	5	100
Virginia	62	1,474	1,312	29	571
Washington	45	1,153	1,070	25	753
West Virginia	22	715	632	20	697
Wisconsin	48	1,489	1,109	33	1,014
Wyoming	6	207	203	4	170
District of Columbia	91	3,792	3,461	18	1,538
Puerto Rico	25	734	705	4	77
Total	2,791	98,712	81,882	1,597	46,966

Geographic distribution of grants and proposals, fiscal year 1963—Continued

[Percentage distributions]

State	Amount granted as percentage of total requested	Percentage of total United States	
		Amount requested	Amount granted
Alabama	55.2	0.9	0.9
Alaska	70.6	.1	.1
Arizona	71.8	1.0	1.3
Arkansas	58.5	.4	.4
California	51.2	8.2	7.5
Colorado	56.7	4.2	4.5
Connecticut	53.2	1.1	1.0
Delaware	41.2	.2	.2
Florida	53.1	1.6	1.5
Georgia	66.3	1.4	1.7
Hawaii	89.5	.3	.5
Idaho	68.1	.3	.3
Illinois	55.3	4.8	4.7
Indiana	72.2	2.3	3.0
Iowa	59.5	1.6	1.7
Kansas	52.7	2.0	1.8
Kentucky	52.9	.7	.6
Louisiana	43.1	2.2	1.7
Maine	60.2	.6	.6
Maryland	50.7	.8	.7
Massachusetts	55.2	7.3	7.3
Michigan	54.6	3.5	3.4
Minnesota	66.6	1.6	1.9
Mississippi	49.3	1.0	.9
Missouri	59.7	2.0	2.1
Montana	54.5	.5	.5
Nebraska	86.5	.3	.5
Nevada	64.0	.1	.1
New Hampshire	69.4	.4	.5
New Jersey	50.2	2.1	2.0
New Mexico	62.8	1.3	1.5
New York	55.7	9.2	9.0
North Carolina	61.1	2.7	2.9
North Dakota	69.8	.7	.8
Ohio	61.7	3.6	3.9
Oklahoma	37.6	3.5	2.3
Oregon	64.3	1.5	1.7
Pennsylvania	43.3	5.1	4.1
Rhode Island	88.9	.6	.7
South Carolina	49.3	.7	.6
South Dakota	74.2	.7	.9
Tennessee	51.4	2.2	2.0
Texas	51.5	3.6	3.3
Utah	84.3	.7	1.0
Vermont	66.0	.2	.3
Virginia	65.3	1.4	1.6
Washington	56.2	1.3	1.3
West Virginia	44.8	1.0	.8
Wisconsin	44.2	1.7	1.4
Wyoming	53.8	.3	2.5
District of Columbia	64.7	3.6	4.2
Puerto Rico	87.0	.6	.8
Total	56.2	100.0	100.0

NOTE.—Detail may not add to total because of rounding.

Geographic distribution of grants and proposals, fiscal year 1964

SCIENCE EDUCATION PROGRAMS (EXCLUDES FELLOWSHIPS)

[Dollars in thousands]

State	Grants			Declinations	
	Number	Amount requested	Amount granted	Number	Amount requested
Alabama	39	$1,133	$831	35	$776
Alaska	9	119	115	3	11
Arizona	29	1,474	963	18	561
Arkansas	43	715	570	20	227
California	228	10,042	7,023	95	2,737
Colorado	81	4,044	2,975	33	1,270
Connecticut	40	1,304	921	11	217
Delaware	9	243	152	7	187
Florida	62	1,567	1,171	39	1,296
Georgia	67	1,985	1,616	35	796
Hawaii	15	486	425	4	24
Idaho	14	415	285	6	204
Illinois	140	4,796	4,410	57	1,379
Indiana	128	3,577	2,837	65	1,364
Iowa	82	2,079	1,490	33	471
Kansas	75	2,255	1,639	34	927
Kentucky	46	858	672	39	673
Louisiana	80	1,825	1,525	52	1,221
Maine	24	642	538	9	199
Maryland	34	875	619	14	586
Massachusetts	138	4,459	2,829	50	1,285
Michigan	144	4,530	3,589	67	1,620
Minnesota	77	2,975	2,672	25	361
Mississippi	33	1,185	897	23	533
Missouri	78	2,315	1,552	47	953
Montana	31	679	540	15	233
Nebraska	26	750	566	18	374
Nevada	11	356	158	4	35
New Hampshire	26	542	537	11	273
New Jersey	90	2,891	1,903	55	863
New Mexico	40	1,593	1,300	22	370
New York	288	8,187	5,796	131	4,069
North Carolina	96	2,523	2,039	63	1,321
North Dakota	35	828	698	16	186
Ohio	156	4,819	3,349	75	1,374
Oklahoma	78	2,744	2,003	56	1,794
Oregon	54	1,684	1,332	27	543
Pennsylvania	212	7,124	4,279	113	2,102
Rhode Island	25	869	648	8	119
South Carolina	31	931	679	12	153
South Dakota	32	995	886	11	166
Tennessee	91	2,063	1,555	50	1,154
Texas	135	4,007	3,110	84	2,524
Utah	29	982	917	14	136
Vermont	23	363	323	4	47
Virginia	78	1,854	1,425	36	675
Washington	64	1,914	1,391	29	513
West Virginia	32	715	576	18	619
Wisconsin	70	1,658	1,071	41	947
Wyoming	8	327	217	1	24
District of Columbia	38	942	661	19	760
Puerto Rico	28	715	693	8	105
Total	3,542	108,953	80,968	1,762	41,367

Geographic distribution of grants and proposals, fiscal year 1964—Continued

[Percentage distribution]

State	Funds granted as percentage of funds requested	Percentage of total United States	
		Amount requested	Amount granted
Alabama	43.5	1.3	1.0
Alaska	88.5	.1	.1
Arizona	47.4	1.4	1.1
Arkansas	60.5	.6	.7
California	55.0	8.5	8.6
Colorado	56.3	3.5	3.6
Connecticut	60.5	1.0	1.1
Delaware	35.4	.3	.2
Florida	41.0	1.9	1.4
Georgia	58.2	1.8	2.0
Hawaii	83.3	.3	.5
Idaho	46.1	.4	.3
Illinois	71.5	4.1	5.4
Indiana	57.5	3.3	3.5
Iowa	58.5	1.7	1.8
Kansas	51.5	2.1	2.0
Kentucky	43.8	1.0	.8
Louisiana	50.0	2.0	1.9
Maine	64.0	.6	.7
Maryland	43.2	1.0	.8
Massachusetts	49.7	3.8	3.5
Michigan	48.4	4.0	4.4
Minnesota	80.0	2.2	3.3
Mississippi	51.6	1.1	1.1
Missouri	47.6	2.2	1.9
Montana	59.0	.6	.7
Nebraska	49.4	.7	.7
Nevada	40.5	.3	.2
New Hampshire	66.0	.5	.7
New Jersey	39.9	3.1	2.4
New Mexico	66.2	1.3	1.6
New York	47.1	8.1	7.1
North Carolina	52.9	2.6	2.5
North Dakota	68.8	.7	.9
Ohio	54.0	4.1	4.1
Oklahoma	44.3	3.0	2.5
Oregon	59.8	1.5	1.6
Pennsylvania	46.3	6.1	5.3
Rhode Island	65.5	.6	.8
South Carolina	62.4	.7	.8
South Dakota	79.5	.8	1.0
Tennessee	48.5	2.1	1.9
Texas	47.7	4.3	3.8
Utah	83.0	.7	1.1
Vermont	78.8	.3	.4
Virginia	56.4	1.7	1.8
Washington	57.4	1.6	1.7
West Virginia	43.9	.9	.7
Wisconsin	41.2	1.7	1.3
Wyoming	62.0	.2	.3
District of Columbia	38.8	1.1	.8
Puerto Rico	84.0	.5	.9
Total	57.7	100.0	100.0

NOTE.—Detail may not add to total because of rounding.

Geographic distribution of grants and proposals, fiscal year 1965

SCIENCE EDUCATION PROGRAMS (EXCLUDES FELLOWSHIPS)

[Dollars in thousands]

State	Grants			Declinations	
	Number	Amount requested	Amount granted	Number	Amount requested
Alabama	51	$1,490	$1,009	36	$737
Alaska	7	240	140	9	211
Arizona	37	1,796	1,121	24	564
Arkansas	29	749	493	29	407
California	255	15,699	8,239	125	3,434
Colorado	80	5,065	2,738	33	1,210
Connecticut	44	1,716	962	22	284
Delaware	13	421	242	6	264
Florida	69	2,400	1,298	55	2,191
Georgia	62	2,824	1,934	42	844
Hawaii	20	719	519	11	160
Idaho	19	453	383	6	124
Illinois	182	10,980	6,470	73	1,662
Indiana	113	4,389	3,015	71	2,463
Iowa	66	2,196	1,501	50	810
Kansas	71	2,433	1,717	50	1,377
Kentucky	39	895	640	35	514
Louisiana	85	2,320	1,787	59	1,447
Maine	21	698	514	12	283
Maryland	41	1,553	937	20	342
Massachusetts	166	15,391	6,949	71	2,259
Michigan	136	6,829	5,066	90	1,562
Minnesota	82	3,661	2,668	43	952
Mississippi	32	1,179	838	28	758
Missouri	78	3,311	1,830	71	1,125
Montana	24	710	475	19	297
Nebraska	23	815	530	15	383
Nevada	12	280	180	7	28
New Hampshire	24	591	522	13	346
New Jersey	102	3,568	2,265	59	945
New Mexico	31	1,108	701	36	1,101
New York	334	18,018	8,870	180	3,175
North Carolina	96	3,773	2,582	73	1,470
North Dakota	40	1,069	744	24	296
Ohio	152	5,213	3,310	81	1,750
Oklahoma	77	3,610	2,078	61	1,821
Oregon	67	2,150	1,754	28	637
Pennsylvania	226	7,025	4,325	142	5,650
Rhode Island	33	1,329	840	11	803
South Carolina	26	1,011	680	18	333
South Dakota	40	1,160	944	16	270
Tennessee	90	2,416	1,875	70	3,580
Texas	147	5,471	3,379	106	2,294
Utah	33	1,526	966	14	488
Vermont	25	423	316	12	161
Virginia	62	2,153	1,271	39	1,133
Washington	59	2,865	1,814	38	666
West Virginia	24	597	285	19	589
Wisconsin	70	2,825	1,585	57	1,051
Wyoming	19	594	412	12	202
District of Columbia	80	4,814	3,755	19	403
Puerto Rico	23	589	566	8	196
Guam	2	16	12		
Total	3,739	165,126	99,986	2,248	56,053

Geographic distribution of grants and proposals, fiscal year 1965—Continued

[Percentage distributions]

State	Amount granted as percentage of total requested	Percentage of total United States	
		Amount requested	Amount granted
Alabama	44.5	1.0	1.0
Alaska	31.0	.2	.1
Arizona	47.5	1.1	1.1
Arkansas	43.0	.5	.5
California	43.1	8.7	8.2
Colorado	43.7	2.8	2.7
Connecticut	48.1	.9	1.0
Delaware	35.4	.3	.2
Florida	28.3	2.1	1.3
Georgia	52.7	1.7	1.9
Hawaii	59.0	.4	.5
Idaho	66.4	.3	.4
Illinois	51.2	5.7	6.5
Indiana	44.0	3.1	3.0
Iowa	50.0	1.4	1.5
Kansas	45.0	1.7	1.7
Kentucky	45.5	.6	.6
Louisiana	45.3	1.7	1.8
Maine	52.3	.4	.5
Maryland	49.2	.9	.9
Massachusetts	39.3	7.9	6.9
Michigan	60.4	3.8	5.0
Minnesota	58.0	2.1	2.7
Mississippi	43.0	.8	.8
Missouri	41.3	2.0	1.8
Montana	47.2	.5	.5
Nebraska	44.3	.5	.5
Nevada	58.4	.1	.2
New Hampshire	55.7	.4	.5
New Jersey	50.2	2.0	2.3
New Mexico	31.8	.9	.7
New York	42.0	9.5	8.9
North Carolina	49.3	2.4	2.6
North Dakota	52.5	.6	.7
Ohio	33.3	4.5	3.3
Oklahoma	38.3	2.4	2.1
Oregon	63.0	1.3	1.8
Pennsylvania	34.9	5.7	4.3
Rhode Island	39.4	.9	.8
South Carolina	50.7	.6	.7
South Dakota	65.9	.6	.9
Tennessee	31.3	2.7	1.9
Texas	43.5	3.5	3.4
Utah	48.0	.9	1.0
Vermont	54.2	.3	.3
Virginia	38.7	1.5	1.3
Washington	51.4	1.6	1.8
West Virginia	24.1	.5	.3
Wisconsin	41.0	1.7	1.6
Wyoming	51.8	.4	.4
District of Columbia	71.6	2.4	3.8
Puerto Rico	72.2	.4	.6
Guam	75.0	[1] 0	[1] 0
Total	46.3	100.0	100.0

[1] Less than 0.05 percent.

NOTE.—Detail may not add to total because of rounding.

Distribution of institutional base grant funds by State, 1961–65

State	Institutional grant funds									
	1961		1962		1963		1964		1965	
	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent	Amount	Percent
Alabama	$1,600	0.1	$11,965	0.3	$47,011	0.6	$56,592	0.5	$61,409	0.5
Alaska	9,700	.6	24,492	.7	45,024	.6	53,910	.5	109,820	1.0
Arizona	18,070	1.2	46,261	1.2	81,316	1.1	137,894	1.2	139,554	1.2
Arkansas	4,350	.3	8,389	.2	23,650	.3	37,906	.3	37,807	.3
California	197,517	13.2	434,380	11.6	795,732	10.4	1,273,267	11.2	1,329,469	11.6
Colorado	19,146	1.3	61,496	1.6	121,673	1.6	225,058	2.0	190,744	1.7
Connecticut	32,580	2.2	75,313	2.0	134,435	1.8	232,186	2.0	240,362	2.1
Delaware	2,970	.2	10,936	.3	26,559	.3	44,560	.4	26,913	.2
District of Columbia	9,389	.6	46,729	1.3	117,875	1.5	65,999	.6	126,610	1.1
Florida	37,493	2.5	81,430	2.2	188,110	2.5	325,623	2.9	301,952	2.6
Georgia	16,548	1.1	49,968	1.3	80,660	1.1	109,536	1.0	121,508	1.1
Hawaii	7,450	.5	15,190	.4	38,450	.5	85,923	.8	105,857	.9
Idaho	2,223	.1	18,613	.5	41,948	.6	24,657	.2	36,409	.3
Illinois	100,496	6.7	202,437	5.4	379,137	4.9	589,425	5.2	571,202	5.0
Indiana	56,490	3.8	140,386	3.8	217,334	2.9	356,439	3.1	363,201	3.2
Iowa	19,774	1.3	53,397	1.4	107,775	1.4	222,798	2.0	144,812	1.3
Kansas	22,010	1.5	49,873	1.3	102,475	1.3	142,183	1.3	175,180	1.5
Kentucky	7,955	.5	31,130	.8	54,358	.7	94,882	.8	111,479	1.0
Louisiana	16,989	1.1	46,399	1.2	127,789	1.7	159,366	1.4	144,644	1.3
Maine	1,395	.1	16,805	.5	30,442	.4	26,668	.2	40,253	.4
Maryland	33,881	2.8	71,927	1.9	170,763	2.2	249,168	2.2	231,284	2.0
Massachusetts	121,418	8.1	231,509	6.2	443,703	5.8	736,384	6.5	658,915	5.8
Michigan	59,175	4.0	102,602	2.7	208,898	2.7	412,998	3.6	391,798	3.4
Minnesota	35,253	2.4	79,765	2.1	132,205	1.7	202,306	1.8	208,104	1.8
Mississippi	1,005	.7	11,355	.3	53,114	.7	38,110	.3	35,269	.3

Missouri	27, 620	1.8	65, 857	1.8	144, 832	1.9	206, 551	1.8	254, 172	2.2
Montana	3, 645	.2	14, 521	.4	43, 293	.6	45, 864	.4	50, 917	.4
Nebraska	7, 005	.5	21, 464	.6	32, 200	.4	46, 296	.4	55, 394	.5
Nevada	235	.02	8, 655	.2	19, 784	.3	31, 066	.3	23, 631	.2
New Hampshire	19, 960	1.3	39, 474	1.1	57, 595	.8	94, 542	.8	118, 096	1.0
New Jersey	43, 606	3.0	89, 033	2.4	195, 932	2.6	321, 024	2.8	307, 205	2.7
New Mexico	6, 230	.4	25, 825	.7	72, 374	1.0	130, 173	1.2	112, 968	1.0
New York	140, 764	9.4	362, 605	9.7	800, 111	10.5	1, 275, 132	11.2	1, 194, 971	10.5
North Carolina	33, 210	2.2	78, 118	2.1	147, 639	1.9	285, 343	2.5	233, 109	2.0
North Dakota	3, 640	.2	15, 075	.4	26, 339	.3	37, 506	.3	25, 158	.2
Ohio	48, 538	3.2	148, 372	4.0	353, 508	4.6	395, 292	3.5	480, 693	4.2
Oklahoma	15, 194	1.0	35, 513	1.0	78, 401	1.0	94, 017	.8	84, 054	.7
Oregon	27, 502	1.8	97, 170	2.6	166, 149	2.2	252, 329	2.2	273, 774	2.4
Pennsylvania	93, 167	6.2	252, 392	6.8	499, 353	6.6	723, 694	6.4	732, 259	6.4
Rhode Island	12, 939	.9	43, 053	1.2	78, 945	1.0	119, 705	1.1	169, 022	1.5
South Carolina	1, 954	.1	27, 575	.7	47, 159	.6	51, 132	.5	37, 144	.3
South Dakota	1, 590	.1	11, 935	.3	40, 558	.5	38, 436	.3	33, 583	.3
Tennessee	17, 260	1.2	39, 165	1.0	113, 428	1.5	144, 830	1.3	114, 484	1.0
Texas	46, 593	3.1	150, 173	4.0	323, 982	4.2	411, 390	3.6	410, 989	3.6
Utah	13, 147	.9	37, 494	1.0	89, 543	1.2	90, 841	.8	136, 533	1.2
Vermont	6, 116	.4	13, 305	.4	46, 761	.6	27, 291	.2	30, 970	.3
Virginia	7, 464	.5	51, 449	1.4	128, 699	1.7	136, 498	1.2	156, 696	1.4
Washington	40, 471	2.7	92, 472	2.5	176, 473	2.3	237, 422	2.1	226, 377	2.0
West Virginia	1, 792	.1	9, 717	.3	30, 699	.4	25, 955	.2	35, 655	.3
Wisconsin	41, 427	2.8	67, 175	1.8	112, 450	1.5	197, 671	1.7	190, 124	1.7
Wyoming	580	.04	5, 080	.1	16, 689	.2	17, 120	.2	11, 568	.1
Puerto Rico			5, 130	.1	12, 981	.2	14, 437	.1	13, 560	.1
Total	1, 496, 616	100	3, 730, 634	100.0	[1] 7, 626, 313	100.0	11, 355, 395	100.0	11, 417, 659	100.0

[1] Includes 1963 amendments of $12,988 funded from fiscal year 1964 funds.

NOTE.—Percentage detail may not add to totals because of rounding.

Geographic distribution of grants and proposals, fiscal year 1963

GRADUATE SCIENCE FACILITIES [1]

State	Grants [2]			Declinations [2]	
	Number	Amount requested	Amount granted	Number	Amount declined
Alabama	1	$17,000	$17,000		
Alaska					
Arizona	2	774,000	175,000	2	$84,000
Arkansas	1	563,000	218,000	2	197,000
California	9	1,680,000	1,290,000		
Colorado	4	384,000	485,000	1	220,000
Connecticut	4	1,211,000	808,000	1	800,000
Delaware	1	193,000	187,000		
District of Columbia				1	85,000
Florida	4	701,000	518,000	2	681,000
Georgia	2	82,000	107,000		
Hawaii					
Idaho					
Illinois	9	5,860,000	3,718,000	3	408,000
Indiana	6	1,915,000	1,118,000	2	751,000
Iowa	3	2,562,000	2,461,000	1	119,000
Kansas	1	29,000	29,000		
Kentucky	2	31,000	32,000		
Louisiana	1	38,000	38,000		
Maine					
Maryland	1	683,000	451,000		
Massachusetts	7	3,272,000	1,859,000	6	1,300,000
Michigan	6	1,935,000	1,933,000	2	1,370,000
Minnesota	7	963,000	938,000	1	16,000
Mississippi					
Missouri	5	1,249,000	619,000	3	1,733,000
Montana					
Nebraska					
Nevada					
New Hampshire	2	826,000	865,000		
New Jersey	2	754,000	706,000	3	414,000
New Mexico	1	8,000	8,000		
New York	9	3,939,000	2,717,000	2	427,000
North Carolina	4	841,000	683,000	1	86,000
North Dakota	1	489,000	100,000		
Ohio	8	470,000	506,000	2	590,000
Oklahoma	6	1,497,000	993,000	1	148,000
Oregon	4	1,166,000	683,000		
Pennsylvania	9	1,278,000	1,110,000	7	2,243,000
Puerto Rico					
Rhode Island	2	1,434,000	762,000		
South Carolina					
South Dakota	3	155,000	69,000		
Tennessee	2	798,000	605,000	1	578,000
Texas	5	412,000	382,000	2	640,000
Utah	2	264,000	264,000		
Vermont				1	216,000
Virginia	3	208,000	208,000	1	315,000
Washington	4	380,000	239,000	1	26,000
West Virginia	1	11,000	11,000		
Wisconsin	1	1,563,000	1,200,000		
Wyoming					

[1] Includes construction of new or the renovation of existing research and graduate level instructional laboratories and demonstration areas, and the acquisition of apparatus required for advanced training and research projects.
[2] Amounts rounded off to nearest thousand.

Geographic distribution of grants and proposals, fiscal year 1963—Continued

[Percentage distributions]

State	Amount granted as percentage of total requested [1]	Percentage of total United States [2]		
		Amount requested	Amount granted	Amount declined
Alabama	100.0	(3)	(3)	----
Alaska	----	----	----	----
Arizona	22.6	1.2	0.3	0.1
Arkansas	38.7	.9	.3	.3
California	76.8	2.6	2.0	----
Colorado	126.3	.6	.7	.3
Connecticut	66.7	1.9	1.2	1.2
Delaware	96.9	.3	.3	----
District of Columbia	----	----	----	.1
Florida	73.9	1.1	.8	1.0
Georgia	130.5	.1	.2	----
Hawaii	----	----	----	----
Idaho	----	----	----	----
Illinois	63.4	9.0	5.7	.6
Indiana	58.4	3.0	1.7	1.2
Iowa	96.1	4.0	3.8	.2
Kansas	100.0	(3)	(3)	----
Kentucky	103.2	(3)	(3)	----
Louisiana	100.0	.1	.1	----
Maine	----	----	----	----
Maryland	66.0	1.1	.7	----
Massachusetts	56.8	5.0	2.9	2.0
Michigan	99.9	3.0	3.0	2.1
Minnesota	97.4	1.5	1.4	(3)
Mississippi	----	----	----	----
Missouri	49.6	1.9	1.0	2.7
Montana	----	----	----	----
Nebraska	----	----	----	----
Nevada	----	----	----	----
New Hampshire	104.7	1.3	1.3	----
New Jersey	93.6	1.2	1.1	.6
New Mexico	100.0	(3)	(3)	----
New York	69.0	6.1	4.2	.7
North Carolina	81.2	1.3	1.1	.1
North Dakota	20.4	.8	.2	----
Ohio	107.7	.7	.8	.9
Oklahoma	63.3	2.3	1.5	.2
Oregon	58.6	1.8	1.1	----
Pennsylvania	86.9	2.0	1.7	3.5
Puerto Rico	----	----	----	----
Rhode Island	53.1	2.2	1.2	----
South Carolina	----	----	----	----
South Dakota	44.5	.2	.1	----
Tennessee	75.8	1.2	.9	.9
Texas	92.7	.6	.6	1.0
Utah	100.0	.4	.4	----
Vermont	----	----	----	.3
Virginia	100.0	.3	.3	.5
Washington	62.9	.6	.4	(3)
West Virginia	100.0	(3)	(3)	----
Wisconsin	76.8	2.4	1.8	----
Wyoming	----	----	----	----

[1] Based on amounts granted during fiscal year 1963 and the amounts requested independent of the year of receipt of the proposals.
[2] Based on total requested received during fiscal year 1963 and the amounts awarded or declined independent of the year of receipt of the proposals.
[3] Less than 0.05 percent.

Geographic distribution of grants and proposals, fiscal year 1964

GRADUATE SCIENCE FACILITIES [1]

State	Grants [2]			Declinations [2]	
	Number	Amount requested	Amount granted	Number	Amount declined
Alabama	1	$39,000	$39,000		
Alaska	1	741,000	665,000		
Arizona	3	57,000	57,000	1	$85,000
Arkansas					
California	13	7,638,000	6,635,000	3	1,566,000
Colorado	3	2,606,000	1,606,000	1	410,000
Connecticut	2	78,000	88,000	1	408,000
Delaware					
District of Columbia	1	227,000	249,000	1	220,000
Florida	4	2,742,000	1,632,000	2	395,000
Georgia	3	17,000	17,000	3	1,212,000
Hawaii	1	84,000	84,000		
Idaho				1	67,000
Illinois	6	2,559,000	1,304,000	8	5,078,000
Indiana	4	235,000	243,000	4	1,177,000
Iowa	2	1,481,000	1,126,000	1	147,000
Kansas	4	291,000	324,000	2	628,000
Kentucky				1	308,000
Louisiana				1	15,000
Maine	1	2,000	2,000		
Maryland	1	522,000	418,000	1	136,000
Massachusetts	7	1,496,000	1,234,000	4	1,020,000
Michigan	1	11,000	11,000	4	3,825,000
Minnesota	1	114,000	101,000	1	1,151,000
Mississippi	1	123,000	128,000		
Missouri	3	828,000	828,000	4	1,708,000
Montana	1	7,000	5,000		
Nebraska					
Nevada					
New Hampshire	3	469,000	367,000	2	308,000
New Jersey					
New Mexico	3	654,000	564,000	2	773,000
New York	14	9,556,000	4,930,000	1	145,000
North Carolina	4	1,568,000	558,000		
North Dakota	2	281,000	112,000	1	39,000
Ohio	4	484,000	447,000	3	1,746,000
Oklahoma	3	204,000	146,000		
Oregon	3	61,000	62,000		
Pennsylvania	8	1,142,000	585,000	7	2,279,000
Puerto Rico					
Rhode Island	4	303,000	327,000		
South Carolina					
South Dakota	2	18,000	16,000		
Tennessee				1	18,000
Texas	7	2,630,000	2,384,000	3	4,349,000
Utah	1	295,000	197,000	1	92,000
Vermont					
Virginia	2	61,000	61,000		
Washington	5	1,300,000	1,166,000	2	800,000
West Virginia	1	318,000	100,000		
Wisconsin	3	2,259,000	1,644,000		
Wyoming					

[1] Includes construction of new or the renovation of existing research and graduate level instructional laboratories and demonstration areas, and the acquisition of apparatus required for advanced training and research projects.

[2] Amounts rounded off to nearest thousand.

Geographic distribution of grants and proposals, fiscal year 1964—Continued

[Percentage distributions]

State	Amount granted as percentage of total requested [1]	Percentage of total United States [2]		
		Amount requested	Amount granted	Amount declined
Alabama	100.0	(3)	(3)	----
Alaska	89.7	0.7	0.6	----
Arizona	100.0	.1	.1	0.1
Arkansas	----	----	----	----
California	86.9	7.0	6.1	1.4
Colorado	61.6	2.4	1.5	.4
Connecticut	112.8	.1	.1	.4
Delaware	----	----	----	----
District of Columbia	109.7	.2	.2	.2
Florida	59.5	2.5	1.5	.4
Georgia	100.0	(3)	(3)	1.1
Hawaii	100.0	.1	.1	----
Idaho	----	----	----	.1
Illinois	51.0	2.3	1.2	4.6
Indiana	103.4	.2	.2	1.1
Iowa	76.0	1.3	1.0	.1
Kansas	111.3	.3	.3	.6
Kentucky	----	----	----	.3
Louisiana	----	----	----	(3)
Maine	100.0	(3)	(3)	----
Maryland	80.1	.5	.5	.1
Massachusetts	87.5	1.4	1.1	.9
Michigan	100.0	(3)	(3)	3.5
Minnesota	88.6	.1	.1	1.1
Mississippi	104.1	.1	.1	----
Missouri	100.0	.8	.8	1.6
Montana	71.4	(3)	(3)	----
Nebraska	----	----	----	----
Nevada	----	----	----	----
New Hampshire	78.2	.4	.3	.3
New Jersey	----	----	----	----
New Mexico	86.2	.6	.5	.7
New York	51.6	8.8	4.5	.1
North Carolina	35.6	1.4	.5	----
North Dakota	39.9	.3	.1	(3)
Ohio	92.4	.4	.4	1.6
Oklahoma	71.6	.2	.1	----
Oregon	101.6	.1	.1	----
Pennsylvania	51.2	1.0	.5	2.1
Puerto Rico	----	----	----	----
Rhode Island	107.9	.3	.3	----
South Carolina	----	----	----	----
South Dakota	88.9	(3)	(3)	----
Tennessee	----	----	----	(3)
Texas	90.6	2.4	2.2	4.0
Utah	66.8	.3	.2	.1
Vermont	----	----	----	----
Virginia	100.0	.1	.1	----
Washington	89.7	1.2	1.1	.7
West Virginia	31.4	.3	.1	----
Wisconsin	72.8	2.1	1.5	----
Wyoming	----	----	----	----

[1] Based on amounts granted during fiscal year 1964 and the amounts requested independent of the year of receipt of the proposals.
[2] Based on total requests received during fiscal year 1964 and the amounts awarded or declined independent of the year of receipt of the proposals.
[3] Less than 0.05 percent.

Geographic distribution of grants and proposals, fiscal year 1965

GRADUATE SCIENCE FACILITIES [1]

State	Grants [2]			Declinations [2]	
	Number	Amount requested	Amount granted	Number	Amount declined
Alabama				1	$334,000
Alaska					
Arizona	3	$1,192,000	$1,299,000	1	52,000
Arkansas	2	87,000	88,000	1	30,000
California	7	3,331,000	3,338,000	2	2,926,000
Colorado	3	1,273,000	1,258,000	2	1,157,000
Connecticut	3	240,000	159,000		
Delaware				1	189,000
District of Columbia					
Florida	3	3,033,000	1,607,000		
Georgia	3	1,011,000	982,000	1	51,000
Hawaii					
Idaho					
Illinois	5	6,671,000	3,876,000	2	2,412,000
Indiana	6	1,602,000	1,133,000		
Iowa	1	79,000	86,000	1	772,000
Kansas				2	45,000
Kentucky	2	151,000	157,000	1	618,000
Louisiana	2	70,000	70,000	1	115,000
Maine					
Maryland	3	134,000	126,000		
Massachusetts	5	3,208,000	1,548,000	1	522,000
Michigan	3	160,000	160,000	1	2,100,000
Minnesota	3	213,000	164,000	2	1,265,000
Mississippi	1	158,000	158,000		
Missouri	2	167,000	123,000	1	102,000
Montana					
Nebraska					
Nevada				1	1,175,000
New Hampshire	1	4,000	9,000		
New Jersey	1	518,000	446,000	3	6,353,000
New Mexico					
New York	9	6,399,000	2,710,000	3	587,000
North Carolina	5	2,725,000	1,375,000	1	111,000
North Dakota					
Ohio				3	1,232,000
Oklahoma	1	31,000	33,000	2	57,000
Oregon	3	487,000	462,000		
Pennsylvania	11	3,479,000	2,721,000		
Puerto Rico	1	14,000	12,000		
Rhode Island	1	200,000	100,000		
South Carolina	3	1,271,000	787,000		
South Dakota	1	6,000	6,000	1	152,000
Tennessee					
Texas	5	1,124,000	578,000	7	751,000
Utah	1	500,000	500,000		
Vermont					
Virginia	1	47,000	44,000		
Washington	2	62,000	62,000		
West Virginia	1	884,000	500,000	1	14,000
Wisconsin	1	1,872,000	1,256,000	1	1,848,000
Wyoming	1	1,104,000	406,000		

[1] Includes construction of new or the renovation of existing research and graduate level instructional laboratories and demonstration areas, and the acquisition of apparatus required for advanced training and research projects.
[2] Amounts rounded off to nearest thousand.

Geographic distribution of grants and proposals, fiscal year 1965—Continued

[Percentage distributions]

State	Amount granted as percentage of total requested [1]	Percentage of total United States [2]		
		Amount requested	Amount granted	Amount declined
Alabama				0.6
Alaska				
Arizona	109.0	2.0	2.2	.1
Arkansas	101.1	.1	.1	.1
California	100.2	5.7	5.7	5.0
Colorado	98.8	2.2	2.1	2.0
Connecticut	66.2	.4	.3	
Delaware				.3
District of Columbia				
Florida	53.0	5.2	2.7	
Georgia	97.1	1.7	1.7	.1
Hawaii				
Idaho				
Illinois	58.1	11.3	6.6	4.1
Indiana	70.7	2.8	2.0	
Iowa	108.9	.1	.1	
Kansas				.1
Kentucky	104.0	.3	.3	1.0
Louisiana	100.0	.1	.1	.2
Maine				
Maryland	94.0	.2	.2	
Massachusetts	48.2	5.4	2.6	.9
Michigan	100.0	.3	.3	3.6
Minnesota	77.0	.4	.3	2.1
Mississippi	100.0	.3	.3	
Missouri	73.6	.3	.2	.2
Montana				
Nebraska				
Nevada				2.0
New Hampshire	225.0	(3)	(3)	
New Jersey	86.1	.9	.8	10.8
New Mexico				
New York	32.8	10.9	4.6	1.0
North Carolina	50.5	4.6	2.3	.2
North Dakota				
Ohio				2.1
Oklahoma	106.4	.1	.1	.1
Oregon	94.9	.8	.8	
Pennsylvania	78.2	5.9	4.6	
Puerto Rico	85.7	(3)	(3)	
Rhode Island	50.0	.3	.2	
South Carolina	61.9	2.2	1.3	
South Dakota	100.0	(3)	(3)	.2
Tennessee				
Texas	51.4	1.9	1.0	1.3
Utah	100.0	.8	.8	
Vermont				
Virginia	93.6	.1	.1	
Washington	100.0	.1	.1	
West Virginia	56.6	1.5	.8	(3)
Wisconsin	67.1	3.2	2.1	3.1
Wyoming	36.8	1.9	.7	

[1] Based on amounts granted during fiscal year 1965 and the amounts requested independent of the year of receipt of the proposals.
[2] Based on total requests received during fiscal year 1965 and the amounts awarded or declined independent of the year of receipt of the proposals.
[3] Less than 0.05 percent.

Geographic distribution of science development program grants

[Dollars in thousands]

State	Institution	Amount
Arizona	The University of Arizona	$4,045
Colorado	The University of Colorado	3,755
Florida	The University of Florida	4,240
Missouri	Washington University	3,919
New York	University of Rochester	2,550
Ohio	Case Institute of Technology	3,500
	Western Reserve University	3,500
Oregon	University of Oregon	4,000
Texas	William Marsh Rice University	2,390
Virginia	University of Virginia	3,780
Total		35,679

A–22. In the new field of technology utilization, what is the Foundation doing to increase knowledge of this subject? What is its role in this respect, in relation to NASA, the Department of Commerce, and the Atomic Energy Commission?

The National Science Foundation has no primary assigned role in this respect in relation to other Federal agencies which may be concerned. The Foundation does participate in various information exchange programs, and tries to insure that scientific results reported by grantees will be promptly reported in the appropriate journals. In this respect the Foundation's activities in the support of scientific and technical information and in the collection of data on technology are important adjuncts. The regular collection of data on the scientific and technologic effort in industry leads to a better understanding of the patterns of technological activity. In addition, NSF's support of the National Referral Center of the Library of Congress complements the Clearinghouse for Technical Information of the Department of Commerce in providing industry with information on the sources of scientific research activities. NASA, the Atomic Energy Commission, the Department of Commerce, as well as NSF, cooperate in making these centers effective transfer agencies for technical information.

This general field is one in which I believe we should be more active.

B. NSF Organization and Budget

B-1. When the NSF was created in 1950 with a budget limited to $15 million, the National Science Board could, presumably, exercise close supervision over the workings of the Foundation. Since that time, the budget of the Foundation has increased to about $480 million and the Board has delegated much of its authority to the Director, keeping for itself the authority for major policy decisions. In effect, then, the Board serves as a sort of board of governors, and is one of the few nonregulatory agencies with this form of dual (Board and Director) authority and responsibility. The question arises: Is it in the best interest of the country and of science in general to still maintain this dual authority, or would it perhaps be better to have the Director solely responsible for the operation of the Foundation, and have the Board serve in an advisory capacity to the Director (a national science advisory board)?

First let me say that the National Science Board, from its inception, has brought a rare sense of dedication to its task. On some occasions all members have been present at its meetings—never has there failed to a be quorum. Its experience and wisdom have been vital to the evolution of wise policies and programs for the Foundation and have afforded to Government a broad view of the role and needs of science not only in the academic community, but in the country as a whole.

The Board and the Director have always worked together in close and harmonious partnership and no serious problems have arisen. However, the present statute does have certain weaknesses. The statutory distribution of responsibilities and authority between the National Science Board and the Director could make it impossible, in an extreme situation, for the Foundation to act. The Director is appointed by and is responsible to the President and must be responsive to the Congress but, in carrying out his responsibilities he is, by virtue of the present statute, subject to policy and other determinations of the Board. This arrangement, therefore, carries within itself the possibility of the Board being in disagreement with actions proposed by the Director pursuant to policies of the administration and the Director being unable to function because of the reservation to the Board of responsibility for determining policy and for approving grants and contracts.

A more immediate practical problem is that the lodging of these responsibilities in the Board raises the difficulty that the Director is frequently faced with the need for taking actions which should be taken promptly but must await the convening of the Board. Moreover, the broad responsibilities which the present statute vests in the Board places a burden on the individual members who are in intimate touch with Foundation activities only on an intermittent basis. While as a Board they are ultimately responsible, they are quite literally unable to be sure that their responsibility is adequately fulfilled in all

matters. This situation has been somewhat alleviated through the Board having transferred to the Director, pursuant to a recent amendment to the act, much of its burden of detailed decisionmaking; it could be further relieved by amending the act to permit the Board to delegate to the Director or its Executive Committee such of its policymaking functions as it deems desirable.

Within the limits of his responsibilities to the President and the Congress, it seems very unlikely to me that any Director of the National Science Foundation would ever ignore or override the views of a distinguished group appointed by the President, with the advice and consent of the Senate, and representative of scientific research and education activities throughout the country. I do not believe, therefore, that there would be any real difference in the Board's influence stemming from whether it were made advisory or whether it retained its statutory responsibilities. The importance of the Board is not that it has legal authority to make decisions but that as a truly independent body it can forcefully represent the views and needs of the scientific and educational communities. Its independence might even be enhanced if changed to an advisory body since there would then be no constraint on its openly questioning governmental policy with which it did not agree.

B-2. Since the Foundation's budget increased almost $100 million between fiscal years 1963 and 1965 why have both the total and scientific professional personnel remained at or below the fiscal year 1963 levels?

The Foundation's employment level need not rise in direct proportion to increases in appropriations. As the agency matures, NSF has been taking advantage of the increased experience of its staff and of the improvement and standardization of procedures.

In line with this philosophy, a review of position management practices was conducted in 1963 by the Office of the Director which resulted in the adoption of new controls and the issuance of guidelines concerning personnel and position management. The assignment by the Office of the Director of specific employment ceilings for each major subdivision based on a detailed analysis of individual programs is cited. Formerly, only dollar limitations were imposed on the operating offices. Another factor which contributed to the maintenance of a stable employment ceiling was the emphasis given to reviewing the balance of workload among the offices and divisions. These continuing management reviews have led, in some cases, to reductions in staff in several offices which offset increases elsewhere. In addition, the use of consultants serving on an intermittent basis, has contributed to the stability in the employment of full-time employees. The number of consultants has increased in the period 1963-65 from 483 to 587. If the expert services of these highly qualified individuals were not available to the extent they are, the number of full-time employees would have to be increased considerably.

It may also be noted that while the total scientific and professional employment at grade GS-11 and up has remained constant, the quality of this group has been steadily upgraded. From July 1, 1963, to June 31, 1965, the number of scientific and professional employees at grades GS-15 and above has increased by 31. During this period the establishment of the Mohole project office and the Office of Program De-

velopment and Analysis, and the reorganization of the education area into three separate divisions all entailed increases in high-grade scientific and professional positions. It should be emphasized that this augmentation was the result of a deliberate policy designed to strengthen the management and control of our research and education programs, while enhancing our capability for more effective planning.

B-3. How has the Foundation determined the proportion of its budget to be devoted to statistics-gathering and analysis and why has this not grown in proportion to the NSF budget and to the Federal-wide research and development budgets? For example, why has the Foundation allocated more funds for research concerned with science information systems than for analysis and planning of national resources for science and technology?

As is the case with reference to any particular Foundation activity, budget estimates are based upon a number of considerations such as the program's history, the current priority of the function, the estimated cost of any planned expansion or change in the activity, etc. Budget allocations for the Foundation's statistics-gathering and analysis have grown over the past 5 years from a level of $1.6 million in fiscal year 1963 to a level of $2.3 million in fiscal year 1966. The NSF budget over this same period has evolved from approximately $322.5 million in fiscal year 1963 to $480 million in fiscal year 1966. The figures for the total Federal R. & D. obligation for these years are $13.7 billion and $16 billion plus, respectively.

While the rate of growth in allocation of funds for statistics-gathering and analysis is proportional to the growth in NSF's overall budget and greater than that in total Federal R. & D. funds over the same period, the relationship should not be conceived as a rational one. There is, in fact, no obvious reason why there should be any direct relationships between the growth rates.

The advent of new program functions (the science development program, for example) during any period can result in a sharp increment in the Foundation's total budget without having any effect on statistics-gathering and analysis operations. Conversely, one can imagine circumstances where program budgets would remain constant while statistics-gathering operations might be sharply increased.

A large portion of statistics gathering that is required for policy studies is done through Government agency channels, utilizing staff that are on the payrolls of the various agencies. In the case of studies that are done under grants or contracts, these in large measure cover expenses for personal services and are not easily compared in cost to "research concerned with science information systems." In the case of the latter, such research frequently involves the utilization of computer time and the experimental use of various computer systems. If, as in the case with research on the proposed national chemical information system, the problem involves the development of computer systems for handling information, the work is extremely costly.

The importance of statistics gathering and analysis has been recognized in the Foundation in the sense of increasing the number of staff and the level of staff devoted to this function. Likewise, funds allocated for science information functions have been increasing and will increase even further if a major effort regarding "national systems" is launched by the Foundation. However, as has been indicated above,

a comparison between these two portions of the Foundation budget is not a very relevant one.

(See also G-5.)

B-4. Referring again to the charts you introduced at the hearings, please furnish a more detailed explanation of "Executive branch science coordination" (chart No. 3). It shows three boxes representing the President's Science Advisory Committee, the Office of Science and Technology, and the Federal Council for Science and Technology. It would be helpful to have more explicit definitions of the respective functions of these offices. Especially, what is the difference between the Council and OST? Is it necessary to have three such groups operating between the President and the executive departments shown at the bottom of the charts? Why?

The Federal Council is composed of policy level officers of the Federal agencies having research and development functions. Such functions are widely dispersed among the Federal agencies, and there is a need, consequently, for the exchange of information and the coordination and correlation of their programs and procedures. The FCST, therefore, is the principal mechanism for developing interagency articulation of Federal science activities. It is concerned primarily with resolving issues of a multiagency nature by means of the type of coordination which one achieves through detailed discussion of shared problems. It leans heavily on the scientific advice of the President's Science Advisory Committee and the National Academy of Sciences. Through various subcommittees and the staffs of the agencies and of the Office of Science and Technology, it examines areas of primary national interest where a concentrated effort and Government-wide approach is deemed essential, either because of the magnitude of the activity or because of the multiplicity of agencies involved. Whole scientific fields are reviewed with respect to scientific expectation and national goals as well as to possible gaps and overlaps.

The Office of Science and Technology, on the other hand, is a relatively small "staff" group charged with assisting the President in securing the coordination of Federal scientific and technological activities and in evaluating the scientific research programs undertaken by Federal agencies. OST is concerned with national policies of science and technology, both the role of science in policy and the complementary role of policy with respect to science. It also provides staff assistance to the President's Science Advisory Committee, the Federal Council for Science and Technology, and the Science Adviser. An important role of the Director of OST is to serve as an especially significant communications link between the executive branch and the Congress.

The President's Science Advisory Committee is comprised of leading scientists and engineers from outside the Government who review the status of important fields of science utilizing as appropriate special panels whose total membership includes several hundred scientists from all over the country. This arrangement not only brings to bear on Government problems the wisdom and experience of all these individuals, but also is an effective mechanism for communication among scientists in the universities and industries actively engaged in research and development and between them and the Government, thus providing an important clearinghouse for information and ideas. PSAC provides a nongovernmental balance to the advice

and responsibilities of FCST and OST. I believe that each of these three mechanisms performs essential tasks which are both different and complementary. Together they provide valuable assistance in the coordination and evaluation of the widely ranging and necessarily different research and development activities and programs of the Federal Government. They should not be considered as "operating between the President and the executive department," and we tried to design the chart to which you refer (No. 3) so as to avoid this interpretation.

Federal science activities are very varied and undertaken by more than 25 different agencies. Each of the groups listed, I believe, serves a useful function in making these activities more effective.

B–5. Most of the data on the charts appears to be for fiscal 1963. Is there later data which might show significant changes?

Three charts in the presentation we made on June 23–25 refer to 1963. These are the transfer tables for research and development (chart 5) and basic research (chart 7) and a related bar chart on sources of funds for basic research, applied research, development, and R. & D. plant (chart 4) which is derived primarily from transfer table data. Updated tables for 1964, for charts 5 and 7, are not yet available because these transfer tables are based on reports of expenditures by performers of research and development, and survey totals for 1964 on intramural performance of components of research and development at the three non-Federal sectors are not yet in. (See also our response to questions C–8 and C–9.) The "Federal Funds" series of reports, of course, provides forward data on Federal intramural performance; but this is not a sufficient basis for updating a transfer table.

Preliminary estimates from the ongoing 1964 surveys of industry and the universities are expected to become available in the late summer and fall of 1965. It will then become possible to construct transfer tables similar to those in charts 5 and 7 and to establish national totals on expenditures during 1964 for the performance of basic research and research and development. Because the 1964 university survey is the first one in that sector since 1958, significant changes may show up there, but as of August 1, 1965, the returns on hand do not permit a prediction on this.

(See also C–8; C–9.)

*B–7. You also said, "Consideration of this problem will form an important part of a study * * * to be carried out this summer by a panel of the President's Science Advisory Committee." Will this study be made public? What similar studies have been conducted by NSF?*

I understand that any firm conclusions, findings, and recommendations of the President's Science Advisory Committee summer study now in progress will be published. However, Dr. Brooks and his coworkers on the study look upon this current effort as only the first of a number of investigations required before the complex problems to which they are addressing themselves can be understood in sufficient depth so that effective policy can emerge. The work being done this summer will undoubtedly prove helpful in several respects—but one of its main contributions will probably come from the group's recommendations on additional ways of understanding the various policy implications regarding the Federal support of academic research.

The main concerns of the PSAC summer study have, of course, in one fashion or another, been the subjects of continuing study by the Foundation. Most of these have taken the form of staff studies and many are currently in progress. It is no exaggeration to say that the summer study as conceived could not be conducted in the absence of fundamental information resulting from surveys, studies, or compilations of data published by the Foundation and a number of NSF unpublished studies and staff papers. Among the NSF published materials, just to cite a few by way of illustration, are such items as "Federal Funds for Research, Development, and Other Scientific Activities," "Investing in Scientific Progress," and "Scientific and Technical Manpower Resources."

NSF studies dealing with such subjects as the numbers of faculty members and graduate students, current and projected, the structure of support for academic research, Federal and other sources of support of graduate students, and the problems and issues relating to postdoctoral work are all immediately relevant to the topics of the summer study. So are NSF unpublished data on projected academic needs for facilities and information derived from a study still in progress of Federal support of academic research and education in the sciences by agency and by individual institution and classes of institutions.

One key question being examined in the summer study is the rate of increase required in the Federal funding of academic research, science facilities, and graduate education in the sciences. In connection with this subject, I may note that NSF is currently providing support for a study designed to develop a growth model for academic institutions. Another study bearing directly on that subject is now being initiated by the Foundation's staff. The first phase of this activity is designed to determine the feasibility of constructing a model showing the interactions among the factors relevant to Federal financing of academic research, facilities for science, and graduate education in the sciences. This first phase is scheduled to be completed by the close of October.

(See also E–15.)

B–8. To what extent is NSF obliged to accept recommendations by the President's Science Advisory Committee? Since the President's science adviser chairs PSAC, does this imply that NSF policies and programs devoted to this question are really being established by the Chairman of PSAC (who is also Director, Office of Science and Technology)?

There is no legal obligation on the Foundation to accept recommendations made by the President's Science Advisory Committee. On the other hand, the President's Science Advisory Committee is made up of outstanding scientists and its views are entitled to the highest consideration. The fact that the Chairman of PSAC is also the Director of the Office of Science and Technology does not, in any way, imply that the Chairman establishes NSF policy, although, of course, his opinions carry great weight with us. In fact, of course, the Director of the Office of Science and Technology advises the President and should the Foundation be in disagreement with the Director of the Office of Science and Technology, the matter can be placed before the President for decision. Insofar as determination of the

NSF budget is concerned, the Bureau of the Budget and the President's science adviser take active roles. However, the final decision is that of the President. The President's Science Advisory Committee plays no part in this process except insofar it may make recommendations with respect to special needs in science.

B-9. What policy guidelines has the National Science Board promulgated, and how are they implemented by the Foundation?

From its very beginning, the Board has devoted a great deal of thought and discussion to a determination of the policies and programs of the Foundation. After the Board, pursuant to its statutory authority to make policy for the Foundation, has approved a program, it is implemented by the Director as chief executive officer.

The Board has also, from time to time, developed policy guidelines of broader application. Thus, in 1954, the Board established a policy for the Foundation regarding loyalty evaluation as related to the support of unclassified research. Subsequently, a special committee of the National Academy of Sciences established at the request of the executive assistant to the President, recommended a similar policy following which the White House requested all Federal agencies to follow the general guidelines proposed.

Under the terms of the report of the Rubber Producing Facilities Disposal Commission, the Foundation was charged with assuming responsibility for the Government's synthetic rubber research program and evaluating the future role of the Federal Government with respect to research in this field. In meeting this second responsibility, the Board appointed a special commission to make recommendations to it. The report of the special commission making a number of recommendations was approved by the National Science Board in December 1955, was subsequently endorsed by the Office of Defense Mobilization, and was incorporated in the President's message to the Congress on rubber resources, requirements, and research in April 1956. The recommendations of the commission were subsequently implemented by the Foundation, other agencies, and the Congress. Another policy recommended by the National Science Board involved the provision to appropriate Federal agencies of grant authority to support scientific research and to vest title to research equipment in the grantee or contractor. This recommendation was implemented by the enactment of Public Law 85-934 on September 6, 1958.

Another type of implementation of policy recommendations of the National Science Board is that exemplified by the reports "Basic Research, a National Resource" (1954) and "Government-University Relationships in Federally Sponsored Scientific Research and Development" (1958) issued pursuant to section 3(a)(1) of the National Science Foundation Act. In other instances the National Science Board has endeavored to create national science policies through Foundation programs. Thus, in 1960 the establishment of the institutional base grant program by the Foundation pointed up the need for giving academic institutions more flexibility in their science operations and in 1963 the science development program underlined the need for creating new centers of excellence throughout the country.

At a somewhat different level of concern, the Board has, from its earliest days, dealt in depth with policies which guide the Foundation in administering its research grant programs, its fellowship activities,

the facilities support efforts, and so forth. Whenever circumstances appear to require reassessment of an established policy (or its modification) the Board discusses the matter and either reaffirms the existing policy or decides upon a new policy.

Policies enunciated by the Board are in general implemented through the dissemination throughout the Foundation staff (and throughout the scientific community when appropriate) of any revised or new policy positions enunciated by the National Science Foundation.

B–11. As a former member of the Atomic Energy Commission please Director?

Where the action is covered by established policy, the Board has delegated to the Director the approval of fellowships, and of grants and contracts except those which call for extremely large expenditures. The delegation permits the Director to approve or revoke any grant, contract, or other arrangement which (*a*) has an average annual rate of expenditure of $500,000 or less and totals less than $2 million, or (*b*) is for the construction of a facility and amounts to $1 million or less.

The Board has also delegated authority to the Director for the provision of funds for approved programs, such as the academic year institutes program, the Antarctic research program, and the science information exchange program, even though the amount of an individual grant may exceed the limits normally applicable. These, for the most part, are continuing activities, and the Director keeps the Board informed by reporting on progress and expenditures. However, no new programs are undertaken without the approval of the Board.

The Director has also been delegated authority to take final action in relation to grants, contracts, or other arrangements during fiscal years 1966, 1967, and 1968 in respect of providing support for oceanographic research vessels, up to a total of $20 million, without regard to the annual rate of expenditure in an individual grant.

As a result of such delegations, only approximately 50 individual actions are passed on by the Board each year.

B–11. As a former member of the Atomic Energy Commission please compare the functions and responsibilities of the AEC to those of the National Science Board in regard to such matters as agency management, national policymaking, agency policymaking, and internal organization.

The Atomic Energy Commission is a quite different kind of body than the National Science Board. The Commission can more meaningfully be compared to the National Science Foundation as a whole. Whereas the Commission has the full authority and responsibility of the agency, in the Foundation there are shared between the Board and the Director.

The chief executive officer of the Commission, the General Manager, is appointed by and is responsible wholly to the Commission; in contrast, the Director of the Foundation is appointed by and must be responsible to the President, although his actions are subject to policies established by the Board and in many major areas require specific approval of the Board.

The five members of the Commission are full-time Government employees who are forbidden by statute from engaging in any other

business, vocation, or employment. The National Science Board is composed of 24 part-time members and the Director. The part-time members are occupied on business of the Foundation only intermittently; their major occupations and responsibilities lie outside the Government. Because of its part-time nature the Science Board cannot be as conversant with or play as intimate a role in the operations of the agency as does the full-time Atomic Energy Commission. By the same token the Board, with its strong roots in the scientific and academic communities, forms a considerably more independent body than does the Commission, which is a wholly integral part of the executive branch. This independence is enhanced by the fact that, in contrast to the Chairman of the Commission who is designated by the President and serves as such at the pleasure of the President, the Chairman of the Science Board is elected by the Board from among its members.

Below the level of their chief executive officers, the Commission and the Foundation have similar structures, the differences being appropriate to their missions.

The Atomic Energy Commission is the dominant agency in the formulation of national policy in atomic energy matters, although it shares its responsibility in the military sphere with the Department of Defense and in the international field with the State Department. Moreover, the Federal programs in its area, including the development and production of nuclear weapons, are almost entirely effectuated by the Commission itself. Its licensing and regulatory activities add to its dominance in the field.

In addition to formulating policy for the Foundation, the Board recommends broad Federal policies relating to basic research and education and through its statistical surveys and studies of national resources for science the Foundation makes a further contribution to national policy formulation in a broad sense. However, the Board cannot itself determine those general policies; moreover, the Foundation plays only a part in implementing policies in its sphere of activity as it is but one of several agencies involved. Thus, it might be said that, whereas the Atomic Energy Commission has concentrated responsibility and control in a particular sphere and implements almost all the Federal program in that sphere, the Science Foundation has a shared responsibility in a much broader area.

B–12. NSF consultants or members of advisory panels are normally appointed under the authority of section 15(a) of the NSF Act which does not limit the per diem such members may be paid. Other Government agencies do have a statutory maximum per diem rate (for example, DOD is limited to a maximum of about $83 and NASA to $100). What per diem rate does NSF pay its consultants appointed under the authority of section 15(a)? Is there any reason why a statutory maximum rate should not be placed in the act? What amount would you recommend?

The NSF pays its consultants appointed under the authority of section 15(a) up to $75 per diem except under unusual circumstances; up to $100 per diem has been authorized in a few such unusual cases, but only after each specific case has received my personal approval. Within the past year only two consultants (out of more than 500) have been paid at the $100 per diem rate. We feel that it would be

undesirable to put a statutory maximum rate in the act because as matters now stand we have greater flexibility for action which can be utilized if the circumstances warrant. We are somewhat on the conservative side in the fees we pay our consultants and such actions are always taken in a judicious manner. Quite a few of our consultants serve without compensation on the basis that it is a privilege for them to participate and that they feel they owe this contribution to science. If it is felt that a statutory maximum rate should be set, I would recommend $100 per diem at the present time.

B-13. Members of the National Science Board, special commissions, division committees, and the Science Information Council are limited by statute to $50 a day. Isn't it poor policy to pay members of advisory panels more than members of the Board? Should the per diem allowance for members of the National Science Board be increased? To what amount?

The divisional committees have been abolished by Reorganization Plan No. 5 of 1965 and only two special commissions have been created. Of course, NSF will continue to seek the help of "advisory" committees in the various fields of its interest, but these will not necessarily bear a 1-to-1 correspondence to the Foundation's divisions. Thus, the question of payment for divisional committee members requires no answer. The main question, therefore, is whether it is poor policy to have Board members and members of the Science Information Council limited to $50 per day. While these appointments are not accepted with any thought of the amount of recompense (and it almost certainly has no bearing on the caliber of persons who accept appointment), nevertheless, if other changes are made in the National Science Foundation Act, it would seem desirable to remove the statutory limitation on the per diem rate for members of the Board, the Science Information Council and special commissions. No special legislation for this purpose is recommended, however.

C. Support of Basic Research

B–6. In discussing the need for increased support, you testified on June 25 (p. 4 of your statement), "We find that each year we need an overall increase of 15 percent or more in support of research at academic institutions merely to maintain a constant relative level of research effort." On what base is this 15 percent estimated? Does not a constant percentage increase each year represent exponential growth? What fraction of this 15 percent should come from NSF?

E–7. Does the 15-percent growth figure apply also to the support of student education? Does it apply to facilities?

E–6. Will the need for a 15-percent annual growth rate in NSF support for basic research in the universities increase, decrease, or change in any foreseeable trend?

C–6. What has been the actual rate of growth in the Foundation's support of basic research for the last 5 years? What is your projection for the next 5 years?

The 15-percent growth factor for academic research mentioned in the quoted statement was also discussed in the NSF budget submission to the Congress for fiscal year 1966. This growth rate refers to the total *Federal* support of research in universities and colleges proper, rather than to that of *NSF* alone. As I noted in my June 25 testimony, this growth in support can be associated with two factors. The first is the increasing numbers of faculty members and graduate students as colleges and universities expand their enrollments to meet the national needs. It is estimated that the annual increase will be some 8 or 10 percent for the next decade. The second is the increasing cost of research per scientist, primarily because the increasing complexity of research requires the use of more sophisticated equipment and of additional supporting personnel. The annual increase in cost of support per scientist is estimated at some 5 to 7 percent.

Thus, combining these two factors, it was estimated for the fiscal year 1966 that an overall increase of at least 15 percent in total support of research in academic institutions would be needed merely to maintain a constant relative level of research activity in those institutions. A substantial part of this increase was estimated to be provided by Federal agencies that have specific missions to perform, although the budgetary decisions of these agencies for the support of research are quite properly made with primary reference to their mission requirements rather than to the specific need to support science in colleges and universities and may well fall short of a 15-percent increase. (See also our response to questions A–8, C–1, E–9.) A review late in (calendar) 1964 of the budgets being proposed for fiscal year 1966 by these agencies showed that they provided for considerably less than the desired 15-percent increase in the support of academic research. Because of the Foundation's responsibility for the strengthening of basic science and science education, the Presi-

dent adopted the concept that the Foundation's fiscal year 1966 budget for academic research should be sufficiently large to assure the necessary 15-percent increase in overall Federal support of basic research in academic institutions.

Following this principle, the President's budget contained a request for $191 million for basic research project grants, an increase of approximately $70 million above the funds available in fiscal year 1965. The Foundation's appropriation for fiscal year 1966, judging from the actions to date by the Congress, would allow us to assign for this purpose an increase of a little more than half that amount, or about $40 million.

The "15 percent growth figure" of question E-7 is assumed to be the same figure dealt with in question B-6 and in the above discussion. Some of the arguments which lead to the finding that research at academic institutions will need increased support of at least 15 percent annually apply also to the problem of student education and the need for facilities, but others are different so that the needs for growth are not equivalent in all three cases.

Demographic factors lead to increased numbers of graduate students in science and engineering in our universities. This increase is one of the elements used in estimating the future needs of academic research. Although we can project with some confidence the increase of graduate enrollments, we have not yet been able to make any sound estimates as to the increased costs associated with the larger graduate student population.

Because there is a definite correlation between those factors which determine future student costs and those which are associated with academic research, it seems fair to assume that the annual rate of growth in these two areas will be approximately the same. There is no reason to think that the Federal role in supporting graduate students will diminish as the student population increases; there will very likely be some increase in the fraction of student education costs (at the graduate level in science and engineering) borne by the Federal Government. The recent increase in size and scope of the fellowship program funded by the U.S. Office of Education will, of course, help significantly in the task of assuring adequate support levels for advanced students. (In this connection, see also our response to question E-19.)

As we have pointed out in our response to questions D-3, D-4, and D-5, it is useful to divide the consideration of facilities into two parts. Doing so enables us to focus on major research facilities (oceanographic research vessels, particle accelerators, and the like) as one important area and on "space" (new or refurbished research laboratories in the main) as another.

In the case of major research facilities, one cannot assume as tight a coupling between increasing student population and rising costs, as can be reasonably postulated for academic research and for student education costs. Here, however, the output of the educational system must be considered: each year there are turned out more highly qualified young scientists. The rising numbers of research scientists will determine the nature and scale of the research opportunities in which the United States must invest in the national interest. This obviously will require a much larger investment in "hardware."

(I have used the word "investment" advisedly, for I sincerely believe that the tax funds going into such major research facilities can more properly be referred to as "investments" than as "expenditures.")

The analysis of probable trends in costs of major research equipment and facilities leads to a further difficult-to-project factor. It is easily demonstrated that research instrumentation, in general, is becoming more costly all the time—but this fact is observed most strikingly when one looks at the successive generations of radio-telescopes, large-scale computers, particle accelerators, and comparable major items. The cost of the 200-Bev. accelerator now being planned by AEC will probably be of the order of the combined costs of all the accelerators built in the United States up to this time. This may be an extreme case, but it illustrates the point I wish to make. Because of this problem, and because major equipment items will probably continue to require special consideration by the executive branch and by Congress—often on a case-by-case basis—we have not been able to find any way of estimating what the annual rate of increase due to this type of cost increase might be over the next few years.

In our response to questions D–3, D–4, D–5, and D–8, we have discussed the problem of providing additional or refurbished laboratory space for graduate students and their mentors. Here, therefore, I will simply point out that the "growth figure" associated with the increasing needs of this nature is also correlated with the growth of graduate students, as is the growth figure for academic research and for student education. But, in this case, it would seem to me more important to look at the total (absolute) needs that we face than at the question of annual rates of increase of funds. If the estimated $4.3 billion needed in the 1962 to 1973 decade is a reasonably accurate estimate (see D–8), and if the institutions continue to assume (as they mainly have done) that they will have to look to the Federal Government for roughly half of these building needs, the total needed from the various agencies now providing such help will have to rise very substantially above present levels in order to come close to meeting projected requirements.

I do not see any reason why the 15 percent growth factor should be decreased in the near future. But I must make it clear that the 15 percent figure was a "best estimate," as previously described, for meeting the requirements for fiscal year 1966. It seems clear that the trend for an increasing requirement will remain fairly constant, but what is not so clear is the assessment of that trend in terms of a specific annual increment. In my statement of June 24, 1965, I touched on this point as follows:

> Because we recognize fully the imprecise nature of this 15-percent estimate, constant efforts are being made to discover better ways to determine these future needs. For example, consideration of this problem will form an important part of a study of basic research, particularly at the universities, which will be carried out this summer by a panel of the President's Science Advisory Committee. This study is regarded as a significant step in a continuing effort to understand and analyze these problems. The Foundation is partaking in and is providing a major component of the staff work for this effort.[1]

If the National Science Foundation is to be expected and allowed to compensate for "shortfalls" as other agencies drop below the estimated minimal 15-percent annual growth rate, budgetary increments in ex-

[1] See also the response to question B–7.

cess of 15 percent almost surely will be required for NSF for several years to come. This annual percentage increase does represent an exponential growth. However, in due course, the demographic factor of relative rate of growth of "student load" will drop, and that of academic research needs will do the same. But this is not likely to happen for at least another 10 years.

With reference to the Foundation's growth in basic research support, the following table reflects the growth in levels over the last 5 years of NSF support of all basic research (including research project grants, national programs, national research centers and minor contributions from other NSF activities).

NSF obligations for basic research [1]

[In millions of dollars]

	Amount	Relative increase
Fiscal year 1960	$68.4	
Fiscal year 1961	77.3	13
Fiscal year 1962	105.5	49
Fiscal year 1963	144.0	37
Fiscal year 1964 (estimate)	164.8	14
Fiscal year 1965 (estimate)	203.9	24

[1] Federal Funds for Research, Development, and Other Scientific Activities, vol. XIII.

From this table it can be shown that the average annual rate of increase of basic research support by the Foundation over these 5 years was 24.8 percent.

In very recent years the support of basic research through many Federal agencies has not been increasing at a rate which many consider necessary to insure adequate support of basic science. Obviously, this is a crucial consideration with respect to the Foundation and its future budgetary levels. Because of the uncertainty surrounding the aggregate support likely to be available from other agencies, it is very unclear what our projections for basic research should be or can be in the years just ahead. Any projection is especially hazardous when a part of the forecasting is dependent upon the ability of other agencies to meet increasing requirements for basic research. On the basis of a continuation of the present rate of increase, it is estimated that the Foundation's levels of support for basic research will rise from about $255 million in fiscal year 1966 to approximately $620 million in fiscal year 1970.

A–8. Are too many Federal agencies today involved in supporting basic science grants and science education? Is there significant duplication here? Might not the Foundation assume a more central, if not exclusive, role in this regard?

C–1. In your testimony on June 25, you stated: "As time moves on, I see NSF accepting a heavier financial responsibility on behalf of all Federal agencies for an expanding basic science. I believe that all agencies should and will continue to support basic research, as they now do, but NSF is likely to be thought of as the logical agency to meet a major fraction of new and expanding requirements." Are these new and expanding requirements related to national goals and agency missions? If so, should not

the Federal agencies other than NSF continue to expand support for basic sciences?

E-9. Could you furnish fiscal year 1965 data on the total amount of basic and applied research conducted in universities proper and sources of funds? Also, could you compare the trends of growth in the support with growth in faculty and graduate student enrollments?

Support for basic science and for science education is provided in significant amounts by 13 Federal departments and agencies. In some instances, when the research program of an individual scientist is of special pertinence to the mission interests of several agencies, they may cooperate in supporting the work, i.e., support may be provided from multiple sources. This happens most frequently when none of the agencies is able to assume full support for the project.

However, duplicate (in contrast to multiple) support occurs rarely if at all. There are a number of mechanisms within the Federal structure which effectively control and discourage undersirable duplication. (See our response to question B-14—E-8 for details of these mechanisms.)

The statement quoted in question C-1 was made in the context of our full conviction that the expanding needs and requirements of science are indeed related to national goals and objectives. We believe it is axiomatic that in the direct interests of the welfare of the Nation it is necessary to sustain a strong and vigorous science enterprise. This, in turn, depends on maintenance of a healthy system of collegiate and graduate education in the sciences and of a strong and productive basic research effort in our universities. The training of an adequate supply of future scientists and the continuous production of new fundamental scientific knowledge are certainly important national goals. Clearly the National Science Foundation must play a central role in helping to reach these goals.

But also, as has been amply demonstrated during the past two decades, our universities, which are the principal loci of basic research and education, can help to meet important objectives in the missions of many Federal agencies without disservice to academic responsibilities. This relationship should be encouraged and all Federal agencies should participate in helping to meet the expanding needs of academic research; for it is quite clear that these enlarged requirements are indeed related to specific agency missions as well as to broad national goals.

But we believe that the National Science Foundation, in this context, has a special responsibility because its principal mission is "* * * the promotion of basic research and education in the sciences." Accordingly it must be willing and able to accept those aspects of support of academic science which cannot be fully or appropriately assumed by other agencies because of the relatively limited nature of their assigned roles. Only in this way can the Foundation live up to its charge of assuring the health and growth of scientific research and education in America.

Accordingly, we believe that each Federal agency should avail itself, to an extent consistent with its mission, of the opportunities inherent in the support of basic research and science education. But we are also convinced that the welfare of the Nation can be served most ade-

quately if, in the coming years, the Foundation is provided appropriations in sufficient amounts to permit it to really assure the health of basic science, including—importantly—academic science in all significant fields.

The amount of research conducted by universities has, of course, increased very considerably during the past decades. Data for fiscal year 1965 on the total amount of research (basic plus applied) conducted in universities proper and sources of funds are available only *on an estimated basis. Estimated* research expenditures (in current dollars) in universities and colleges proper, by sources of funds, fiscal years 1954 and 1965, are shown in table 1.

TABLE 1.—*Estimated research expenditures, universities and colleges proper, fiscal years 1954 and 1965*

Source of funds	Fiscal year 1954		Fiscal year 1965 [1]		Compound annual rate of increase (percent)
	Amount	Percent distribution	Amount	Percent distribution	
Federal Government	$142	48	$1,050	68	19.9
Industry	15	5	60	4	13.4
Universities and colleges	124	41	330	22	9.3
Other nonprofit institutions	19	6	90	6	15.2
Total research funds	300	100	1,530	100	16.0

[1] NSF staff estimates.

TABLE 2.—*Faculty and graduate student growth, 1954–65*

[In thousands]

	Academic year		Compound annual rate of increase (percent)
	1953-54	1964-65	
Instructional staff [1]	140	246	5.2
Graduate students [2]	219	498	7.8

[1] Full-time-equivalent instructional staff for resident degree-credit courses.
[2] Enrollments in degree-credit courses.

It should be noted that these estimates for fiscal year 1965 are based on secondary sources of information, rather than on data reported by universities and colleges on the amounts and sources of their research funds.[1]

As table 1 indicates, research funds in universities and colleges proper totaled an estimated $1,530 million in fiscal year 1965, compared with $300 million in fiscal year 1954. On the basis of these estimates, we conclude that:

Federal Government research support increased at a somewhat higher rate than other sources of research funds during the 11-year period;

In fiscal year 1965 the Federal Government financed 68 percent of the research performed at universities and colleges proper, compared with 48 percent in fiscal year 1954;

[1] The National Science Foundation is currently conducting a survey of scientific activities of institutions of higher education, 1963–64, which will yield definitive information on the total amount of basic and applied research conducted in universities proper, by source of funds. This survey will yield benchmark data that will make it possible to estimate fiscal year 1965 levels of research funding with increased precision.

The relative share of research financed by "other nonprofit institutions" was the same in both years, industry's portion declined slightly, and the relative amount financed by universities and colleges decreased from 41 percent in fiscal year 1954 to 22 percent in fiscal year 1965.

The proportionate increase in total research funds in universities and colleges proper during 1954–65 (see table 2) exceeded the relative increases in the numbers of faculty and graduate students. In comparing research funds with personnel data, however, several points must be borne in mind. One of these pertains to the relative bases upon which these percentage increases are calculated. In the case of research support, it is to be remembered, the support base in fiscal year 1954 was quite low and the annual increases, in terms of percentage, therefore appear high because the sums required to "catch up," as it were, were relatively large compared to the small starting base.

Secondly, it should be noted that in the comparisons made here, research funds are expressed in "current dollars." This procedure does not take into account the decline in purchasing power that occurred during the 11-year period. (We are making efforts to determine the magnitude of the proper factor to use in determining the "purchasing power" of research dollars at each given point in time—but this proves to be a particularly difficult problem.)

B–14. Witnesses have mentioned that research programs of the different agencies are coordinated in a variety of ways. What are these coordinating mechanisms? Give examples of the coordination among NSF, NASA, NIH, AEC, etc.

E–8. What mechanism exists by which the Foundation can identify existing or proposed support of other Federal agencies to any particular university?

We use a number of different mechanisms "to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research programs with those undertaken by individuals and by public and private research groups.[1] Among these mechanisms are several which help us to identify existing or proposed support by other Federal agencies: (*a*) participation of NSF representatives on interagency committees and panels; (*b*) personal contacts between NSF representatives at the division and program levels and their counterparts in other Federal agencies; (*c*) exchange of proposals and information about proposals on a routine basis; (*d*) reports of Federal agencies concerning grants or contracts awarded; (*e*) reports, bulletins, announcements, and other published or unpublished financial statements of particular universities; and (*f*) surveys of universities and colleges conducted by the National Science Foundation, the U.S. Office of Education, and other Federal or private organizations. Each of the above-mentioned mechanisms is described in the sections that follow. In addition, there is provided at the end of the answer to this question a listing of groups which, in one way or another, are involved in the coordinating process.

A. *Committees and panels.*—Members of the Foundation's research divisions participate in numerous interagency meetings related to particular disciplines of missions. Staff members attending such meetings obtain information regarding current and future programs and

[1] Quoted from sec. 3(a)(6), National Science Foundation Act of 1950.

plans of other agencies. These committees and panels are constituted as part of basic legislation, by executive order, or by joint action of the departments and agencies.

Although there are many of these formal, organized groups which help effectively to coordinate the research programs of different Federal agencies, I shall give only two illustrative examples of their nature and role.

(1) Research in oceanography is coordinated through the Interagency Committee on Oceanography, a Committee of the Federal Council. This Committee, which is chaired by the Assistant Secretary of the Navy for Research and Development, includes all of the Federal agencies which either support oceanography or undertake programs in-house. The Committee reviews annually the proposed budgets and programs of the various agencies and recommends appropriate changes so that the total Federal activity represents a national program.

(2) Another important example of formal cooperation is provided by the Interagency Coordinating Committee on Antarctica, which consists of staff-level representatives of the Departments of State, Defense, Interior, and Commerce, the National Science Foundation, the U.S. Information Agency, the Arms Control and Disarmament Agency, and the Bureau of the Budget. This Committee meets at predetermined intervals to discuss problems of mutual concern and to coordinate activities.

In planning and coordinating the U.S. scientific program in Antarctica, the National Science Foundation has been directed by the Bureau of the Budget to coordinate with the Department of Defense. The Foundation's Office of Antarctica Programs and the U.S. Naval Support Force, Antarctica, are jointly involved in planning the annual effort in Antarctica. A high-level Antarctica Policy Group, representing NSF, DOD, and State reports to the President on antarctic international problems. During the operational period of the antarctic summer, Foundation staff members represent and coordinate the scientific program requirements in the field with the naval commanders responsible for providing logistic support.

B. *Personal contact among agency staff*.—Under informal arrangements, staff members of the Foundation at the division and program levels attend reviewing panels of other agencies as observers. For example, staff members of the NSF genetic biology program sit in on discussions of the NIH Study Section reviewing proposals in that field. A different example is the Interagency Solid State Administrators Group—an informal group which meets bimonthly. In addition to discussing the research programs supported by the various agencies, the Group considers such matters as: ways of reducing possible multiple support of some grantees; a uniform coding system to assure a higher quality of statistical information; and a system whereby appropriate agencies can more efficiently exchange information concerning proposals. A central file of all grants to universities in the general materials field has been activated.

Another example of purposeful coordination is the Interagency Group for Research on Information Systems (IGRIS)—an informal organization for administering research programs in the field of information systems. The group meets regularly to: exchange in-

formation concerning programs, plans, progress, trends, and funding; discuss mutual problems of scientific contract supervision and administration; achieve voluntary coordination of activities by reducing duplication of effort, noting gaps wherein greater effort is desirable, and to make appropriate recommendations when necessary.

Among these coordinative mechanisms, clearly one of the most important is direct person-to-person communication—usually by telephone—between program administrators. Such communication between program directors in different Federal agencies provides assurance that the administrators of programs in various fields of science are well informed on which groups in Government are supporting particular kinds of research and which groups have special interests in certain subfields of a scientific discipline.

Thus it is relatively easy to avoid undesirable overlap of support in terms of either kinds of research or levels of funding. At times mutual agreements are developed which result in coordinated grants by two or more Federal agencies. For example, at the Massachusetts Institute of Technology, a Foundation grant of $375,000 is one important element in a coherent, research-support plan for the Center for Communication Sciences. This center, now in its seventh year, has been supported jointly by NSF, DOD, NASA, and private groups as well.

C. *Exchange of proposals and exchange of information on a routine basis.*—This mechanism was established primarily to identify duplication in proposals to several agencies. However, the exchange of information also involves data on the types, amounts, and other characteristics of the support of other Federal agencies. For example, the Division of Mathematical and Physical Sciences exchanges with a number of other Federal agencies monthly reports on proposals. The Division of Biological and Medical Sciences also collects data from other Federal agencies covering the life sciences. The task of collecting and making information available on current projects is being performed by the Science Information Exchange (SIE). The Science Information Exchange has a file on more than 70,000 research projects in the biomedical, the physical, and the social science fields. These include projects sponsored both by the Federal Government and by other organizations. Among the services that can be provided by the SIE is the listing of federally supported research projects and proposals of particular universities.

The following specific examples will illustrate how certain individual proposals were the subject of close coordination between interested and cognizant groups:

1. A proposal for the support of a new building at a major university was submitted simultaneously to the Science Facilities Section of the NSF and the research facilities program of NIH. After a thorough review by each agency it was agreed that the NIH grant would be for $425,000 and that the NSF grant should total $1,375,000.

2. The Science Facilities Section of NSF received proposals from three universities, each of which requested funds for the construction of housing for accelerators to be furnished by the AEC. On contacting the AEC, NSF learned that only one accelerator award was to be made and AEC agreed to inform NSF when a decision was made as to the recipient of the award. The proposals to house an accelerator

were held until the AEC decision was made, and then (after carrying out an appropriate review) NSF made one facilities grant.

3. The National Science Foundation was requested to provide funds for the development and construction of an electron microscope capable of operating at the ultimate level of theoretical resolution. This achievement should make possible direct observations of molecular structure and provide fundamental information on important biophysical and biochemical processes. NSF funds were too limited to permit full support for this project, but it was possible to assist this research by means of joint support from the National Science Foundation and the National Institutes of Health.

4. Following the Alaska earthquake of March 27, 1964—assessed as one of the most severe of modern times—President Johnson requested his Science Adviser to undertake a comprehensive scientific and technical study of the earthquake and its effects. Dr. Hornig, in turn, requested that the National Academy of Sciences set up a committee to undertake a survey of earthquake effects, to coordinate reports, and to prepare a summary of the scientific, technical, and economic aspects of the disaster. Responsibility for the biological studies was assigned to an oceanography subcommittee which met in December 1964, at the California Academy of Sciences for the purposes of formulating plans for carrying out a biological investigation in the earthquake area. Funds to support a field party to carry out these studies were awarded by the National Science Foundation and the Atomic Energy Commission.

D. *Reports of Federal agencies.*—Federal agencies maintain records and issue reports of various types and in varying detail on grants or contracts awarded. These reports typically contain information describing the type of award, amount, duration, and the name of the principal investigator. Where additional information on the award is needed, it can be obtained by contacting the appropriate official of the awarding agency.

During the past 2 years, Federal agencies have been requested by the Congress to supply data on the amounts of grants and contracts awarded particular universities and colleges on at least two different occasions. For the May–June 1964 hearings of the House Subcommittee on Science, Research, and Development, 5 agencies (AEC, DOD, NASA, NIH, and NSF) were asked to supply data on the 100 universities and colleges proper receiving the largest amounts of awards, and 3 agencies (Agriculture, Commerce, and Interior) were requested to supply the names and amounts of grants and contracts awarded to the 25 institutions receiving the largest amounts. In late 1964, Senator Ribicoff requested that five agencies (AEC, DOD, HEW, NASA, and NSF) provide data on obligations for research, training, and facilities, by educational institution, for fiscal years 1963, 1964, and 1965.

E. *Reports of universities and colleges.*—Virtually all universities and colleges publish financial statements covering their operations during specified fiscal periods. Such financial statements constitute a source of information on all sources of income, including income received from Federal agencies. Even where an institution does not publish publicly financial statements covering its operations, copies of

such statements can usually be obtained upon request. Because such reports cover different periods, are made available at different times, and are in other ways noncomparable, they are of limited usefulness as sources of "national" data; they are nonetheless quite useful as a means of obtaining more or less detailed data on a specific institution.

F. *Surveys of universities and colleges by the National Science Foundation, the U.S. Office of Education, and other organizations.*—The National Science Foundation has conducted a number of surveys of universities and colleges to obtain information on the allocations of scientific and engineering resources. Such surveys obtain data on all sources of support for scientific activities for which information is requested, including support provided by individual Federal agencies. The Foundation is currently engaged in a survey of scientific activities of institutions of higher education, 1963–64, which will provide data on Federal support of R. & D. performance; capital expenditures for research, development, and instruction in the sciences; and expenditures for education in the sciences.

The National Science Foundation conducts an annual survey of Federal funds for research, development, and other scientific activities. This survey collects data from Federal agencies on extramural obligations going to universities and colleges for research, development, and R. & D. plant, but does not request separate figures for each institution.

The U.S. Office of Education conducts a biennial survey of financial statistics of institutions of higher education. A survey covering fiscal year 1964 is currently in progress. This survey collects data on current-fund income and plant-fund income of all universities and colleges, by source of funds. Data reported by individual institutions in this survey are not published.

A number of private organizations also conduct periodic surveys of universities and colleges that yield data on sources of income and expenditures for research, education, and other activities of individual institutions.

The following listing of boards, committees, panels and councils provides a rather wide sampling of the organized research coordinating mechanisms on which Foundation staff serve as members, representatives, observers, or consultants—and which are of direct relevance to the coordination of Federal activities in science and technology. This list (intended to be illustrative only) is presented according to the following headings:

(1) Beneath the heading "Departments and agencies"—and under the names of the agencies—we have listed those groups that are—

(*a*) Wholly or primarily "internal" to a given agency, but whose meetings are attended by NSF observers or "liaison members," and

(*b*) Interagency in character, but normally chaired by a representative of the agency under which the group is listed.

(2) Under "Executive office groups" we have listed a number of committees, councils, etc., which are closely associated with one or more of the units serving as staff to the President.

DEPARTMENTS AND AGENCIES

Department of Commerce:
- Federal Committee for Meteorological Services and Supporting Research.
- Interdepartmental Committee on Applied Meteorological Research.
- Interagency Committee for International Meteorological Programs.

Department of Defense:
- Coordinating Committee on Science (ODDRE).
- Defense Science Board.

Department of Health, Education, and Welfare:
- National Institutes of Health:
  - Health Research Facility Council.
  - Interdepartmental Advisory Panel for the National Center for Health Statistics.
  - National Advisory Allergy and Infectious Diseases Council.
  - National Advisory Arthritis and Metabolic Diseases Council.
  - National Advisory Cancer Council.
  - National Advisory Child Health and Human Development Council.
  - National Advisory Dental Council.
  - National Advisory Heart Council.
  - National Advisory Neurological Diseases and Blindness Council.
- Office of Education:
  - Advisory Committee on Graduate Education.
  - Cooperative Research Panel on Curriculum Development.
  - International Cooperation Year, Committee on Education.
  - Federal Interagency Committee on Education.

Department of the Interior:
- Advisory Committee on Atmospheric Water Resources.

Department of Labor:
- President's Committee on Manpower.
- Committee on Specialized Personnel.

Department of State:
- International Cooperation Year:
  - Committee on Science and Technology.
  - Committee on Natural Resources Conservation and Development.

National Aeronautics and Space Administration:
- Space Sciences Steering Committee.
  - Astronomy Subcommittee.

National Science Foundation:
- Interagency Coordinating Committee, Upper Mantle Project.
- Science Information Exchange Advisory Board.
- Advisory Council for Manpower and Education Studies.
- Interagency Coordinating Committee on Antarctica.
- Science Information Council.

EXECUTIVE OFFICE GROUPS

President's Science Advisory Committee:[1]
- International Science Panel.
- Panel on Scientific and Technical Manpower.

Federal Council for Science and Technology:
- Behavioral Sciences Panel.
- Committee on Long-Range Planning.
- Committee on Scientific and Technical Information.
- Committee on Water Resources Research.
- Coordinating Committee on Materials Research and Development.
- Interagency Committee on Oceanography.
- Interdepartmental Committee for Atmospheric Sciences:
  - ICAS–CIO Joint Panel on Air-Sea Interaction Research.
  - Select Panel on Weather Modification.
- Technical Committee on High Energy Physics.

Office of Science and Technology:
- Interdepartmental Energy Study Steering Committee.
- Panel on Education Research and Development.[2]

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[1] The Director of NSF is frequently invited to attend PSAC meetings as an observer.
[2] This Panel reports to three "Principals": the Director of OST, the Commissioner of Education, and the Director of NSF; it receives staff assistance from OST.

Bureau of the Budget:
Financial Management Advisory Group.
Interagency Committee on Automatic Data Processing.
(See also A–15.)

C–3. What are the fiscal year 1965 estimates in the support of basic research in the universities by Government and by other sources? How does one define "major share"? Will increasing Federal support discourage support by the States and private institutions so that there is less total gain than expected? Should incentives be provided to maintain the current proportion of support between Federal and non-Federal sources?

The fiscal year 1965 estimates for support of basic research in universities and colleges by Federal Government and other sources are shown in the following table:

Estimated expenditures for basic research at colleges and universities proper by source of funds, 1965 [1]

[In millions]

Source of funds:	Colleges and universities proper
Federal Government	$575
Industry	35
Colleges and universities (including State support)	300
Other nonprofit institutions	75
Total	985

[1] Estimates of expenditures are based upon earlier survey data and other sources of information. Estimated expenditures for basic research at Federal contract research centers managed by universities are $145,000,000.

In using the words "major share," I had in mind the existing situation in which the Federal Government supports about three-fifths of basic research conducted at colleges and universities proper. There is no basis for expecting that the proportion of non-Federal support will increase significantly in the near future. Consequently, if academic institutions are to continue to make vital contributions to basic science, Federal expenditures will have to continue to account for about the same proportion of their basic research activities.

There is no persuasive evidence that Federal support has discouraged support by non-Federal sources. On the contrary, a somewhat better case can be made for the view that the Federal Government's commitment to academic scientific research has stimulated support on the part of non-Federal institutions. In fact it has become clear to State and local governments that there are important benefits associated with the growth of academic scientific capabilities. For example, the State of New York recently established a public foundation of science and technology which made grants of about $500,000 in 1964 to support academic research.

The pattern of support of academic research is determined by dynamic forces that are themselves shaped by changing needs, opportunities, and objectives. This pattern of diversified support should be expected to change over time. Federal and non-Federal sources of support represent interacting elements in a dynamic system. The influx of Federal funds into a particular area of research might well alter the pattern of support in that area. Thus, a

private foundation, for example, may divert a fraction of its support from that research in order to stimulate research in a different field.

There is no reason to believe that special incentives should be provided in order to maintain the present ratio of Federal to non-Federal support. In our view it would be unwise to attempt to fix any such ratio. In the years ahead every effort should be made to encourage growth in the whole pattern of support for academic research—both Federal and non-Federal—without regard to any fixed ratio.

C-2. You said also, "there is wide agreement that Federal support of scientific research should expand, particularly in the universities." Does this imply proportionally more basic research should be conducted in the universities? If so, would this mean proportionally less in Government laboratories or in industry? If this is the implication, when and where was this discussed, so as to justify "widespread agreement?"

> *E-4. At the present time approximately 50 percent of the basic research supported by the Federal Government is conducted in universities. Considering our growing Nation and the use of science to serve its needs, do you feel this balance between performers should be changed?*

Perhaps the term "wide agreement" states the situation more strongly than it deserves. Had I used instead the phrase "widespread belief," I now think this would have made the point somewhat more accurately. As will be noted from the comments contained in the NAS report to the Committee on Science and Astronautics entitled "Basic Research and National Goals," the argument for the proposed expansion of basic research support at universities rests in part upon the need to provide research training for increasing numbers of students (and hence for research support of the growing faculty who train them) and on the increasing cost per scientist of performing high caliber research. It is also suggested that support of research in Government-owned laboratories (other than those primarily established to foster academic research) and industrial laboratories should be geared to the needs of the parent organization for research. The level of such support would then be determined in the context of the organization's mission and its available funds. Since the latter criteria are different from those which it is proposed to apply to the universities, there is no reason to think that the proposed increase for the universities would necessarily imply either an increase or a decrease in Government laboratories or in industry.

With respect to those Government laboratories which are highly productive of research results related to the mission of the parent organization (perhaps only in a long-range sense), it is clear that increased yearly support should be provided at whatever rate is warranted by mission needs. Similarly, the level of Federal agency support of basic research in industry should not be tied to the amount of such support in universities, but should be judged on the basis of considerations relevant to the assigned responsibilities of the agencies which support such work.

Therefore, I see no need to recommend that a major change take place in our present pattern of university and nonuniversity performance of basic research. In this regard, however, it is important to recognize that one of the characteristics of a vigorous and productive basic research organization seems to be that it combines the efforts of older, experienced, knowledgeable men and younger men with adventurous and creative minds. Such an organization should also provide an opportunity for men with backgrounds in different but related disciplines to exchange ideas and experimental know-how. These conditions tend to exist naturally at universities. While it is true that they can be created intentionally at a nonteaching laboratory, to do so requires a large and expensive organization. The new staff must either continue to grow or have a deliberate turnover such as that which comes automatically at a university because of graduate students and postdoctoral scientists. Some research efforts—those of a very large and comprehensive nature—simply cannot be appropriately carried out on a university campus. Hence, although we consider participation in research projects by students to be highly desirable, it is not possible to arrange for their involvement in all research efforts. Experiments mounted on large space satellites and probes are illustrative of research projects that must often be carried out at laboratories having little connection with a university.

Inasmuch as Government support of science is committed to the training of manpower as well as to increasing our store of scientific knowledge, we must continue to expend major portions of our research budget at universities.

C–4. How is balance of NSF support determined as between different fields of science disciplines? In this respect, what use is made of the studies of the National Academy of Sciences?

The National Science Foundation has been supporting basic research for a period of nearly 15 years. Decisions as to the distribution of support among the several scientific disciplines are therefore made in the light of a current level of support for each field which represents our cumulative experience. The Foundation constantly receives information from individuals and organizations in the scientific community and from other Government agencies which bears on the adequacy of the support being provided. The Foundation's program directors, each an experienced scientist in his field, are especially sensitive to these "error signals," and make certain that this information is passed through their chain of command to the Director. At the same time information is received directly by the Director and the Board and this too goes into the decision process. It is most important to realize that this process is a continuous one and that continuing efforts are made to improve the distribution.

It is also important to recognize that our decisions are not simply based on response to demand. A conscious effort is made to emphasize those fields where the scientific challenge is greatest and where the time appears to be ripe for major advances. (See also the response to A–17.)

Reports from the National Academy of Sciences are one important "input" from the scientific community. We give them serious consideration in our constant effort to improve our allocation of resources. We have found these reports particularly helpful in identifying needs

for major increases in support for specialized facilities and in connection with the establishment of national centers.

(See also A–15; A–17.)

C–7. A recent change in the language of the appropriation bill for NSF and other agencies provides for cost sharing on research grants, whereas previously there had been a limitation on the amount of reimbursable indirect costs. The question is in six parts:

(a) Do you favor such a change?

In my opinion, the change is desirable. While cost sharing or participation has generally been characteristic in most of the research projects which we have supported, I have always believed that the imposition of a ceiling on indirect costs was not the proper method for achieving cost sharing. University accounting systems differ for a variety of valid reasons and the allocation of costs between the direct and indirect categories therefore follows different patterns at different schools. The limitation on indirect costs has therefore not only been burdensome but inequitable. The removal of the limitation on indirect costs will permit both the Foundation and the universities to implement the cost-sharing principle in a more equitable manner.

(b) Did the universities favor the change?

I do not know whether the academic community was consulted at the time the change was proposed by the House Committee on Appropriations, but university officials have clearly indicated that they certainly favored the removal of the ceiling on overhead reimbursement. Inasmuch as cost sharing was already an established and accepted principle, it is my opinion that the universities would favor the change.

(c) How will this modify the current procedure?

The principal change in procedure will be the identification in a more formal way of the amount contributed by the universities. At the present time their contributions, such as faculty effort for example, are stipulated in the proposals but not always priced out and identified. Should the Congress pass the proposed bill with the cost-sharing requirement included, the contributions of the universities will necessarily be more explicitly shown.

(d) How will the cost-sharing rates be determined?

In the report on the appropriation bill for the Department of Health, Education, and Welfare, where the cost-sharing requirement was first proposed, it was stipulated that the Bureau of the Budget would develop Government-wide guidelines for the implementation of the new requirement. A full response to this question must await the publication of the guidelines.

(e) Will it differ institution by institution or even project by project at the same institution?

The answer to this question must likewise await the publication of the guidelines by the Bureau of the Budget.

(f) Will the change affect grants currently in existence?

It is not intended that the change affect grants currently in existence. It is our intention to implement the requirement as soon as possible after the appropriation bill is passed, and the guidelines are published.

C–8. Chart No. 7 which you presented shows the contribution of the Federal Government to basic research [at universities proper] to be $380 million. The latest figure in this regard from "Federal

Funds for Science" is around $600 million. This seems to be a big difference. Why isn't the later figure used? Could you extrapolate some of the other figures to give a more current picture?

C–9. The figure shown for Federal sponsorship of basic research is $1.06 billion for 1963. What appears to be the same figure in chart No. 8 for fiscal year 1965 is $1.3 billion.[1] *What is the explanation for this discrepancy?*

These two questions refer to both obligations data from "Federal Funds for Research, Development, and Other Scientific Activities" and expenditures data from the transfer table in chart 7. As background to the answers, it may be useful to describe the basis of the transfer table for basic research, 1963,[2] in chart, and, in particular, to indicate how data were obtained for the first line of the table—on Federal financing. (For ease in reference, chart 7 is again presented below.)

The transfer table is designed to show how *much money was spent during 1963* in the actual performance of basic research in the laboratories of Federal agencies, industry, colleges and universities, and other nonprofit institutions, and the *sources of that money.* National basic research totals must be in terms of expenditures since expenditures are the common denominator used to express inputs, public and private, into all activities in our economy. (Obligations are generally used only in Government budgeting.) An expenditures total for basic research or research and development can be related to other data, such as the gross national product or outlays for education; it can also be related to employment in basic research or research and development to work up cost/manpower ratios. Because data on

BASIC RESEARCH, 1963

Intersectoral Transfers of Funds Used for Performance (Preliminary)
(Millions of Dollars)

SOURCES OF FUNDS USED	BASIC RESEARCH PERFORMERS: FEDERAL GOVERNMENT	INDUSTRY	COLLEGES & UNIVERSITIES: PROPER [a]	COLLEGES & UNIVERSITIES: FED'L CONTR RESEARCH CENTERS	OTHER NONPROFIT INSTITUTIONS	TOTAL	PERCENT DISTRIBUTION, BASIC RESEARCH SOURCES
FEDERAL GOVERNMENT	275	150 [b]	380	150	105 [b]	1,060	58
INDUSTRY	—	350	30	—	20	400	22
COLLEGES & UNIVERSITIES [c]	—	—	220	—	—	220	12
OTHER NONPROFIT INSTITUTIONS [c]	—	—	60	—	75	135	8
TOTAL	275	500 [b]	690	150	200 [b]	1,815	100
PERCENT DISTRIBUTION, BASIC RESEARCH PERFORMANCE	15	28	38	8	11	100	

[a] Includes Agricultural Experiment Stations

[b] This Amount Includes Funds from the Federal Government for Research Centers Administered by Organizations Under Contract with Federal Agencies

[c] Data Include State and Local Government Funds

NOTE: Data are Based on Reports by Performers

Source: National Science Foundation, 1964

[1] Chart 8 shows the fiscal year 1965 total as $1.9 billion rather than $1.3 billion.

[2] In general, the same method is employed in constructing the transfer table on research and development in chart 5.

expenditures are required, information in the transfer table is obtained from performers of basic research since we have learned from experience that only performers know in the required detail how much was actually spent in the conduct of basic research during a given period—and from where the money came.

Information on expenditures is obtained directly from the performers of basic research in each of the four sectors by means of surveys: in the *Federal* and *industry* sectors, the surveys are conducted annually; in the *university* and *other nonprofit* sectors, surveys have heretofore been made less often. For these latter two sectors, NSF staff has made estimates for the nonsurvey years, such as 1963, based on earlier survey data and information from secondary sources. (For this reason, we should perhaps have indicated on charts 5 and 7 that certain data represented estimates.)

The basic research transfer table is constructed by entering in a particular column that sector's total expenditures for basic research broken down by sources of the money spent as indicated in a just-completed sector survey, or as estimated from an earlier survey. Thus, for the colleges and universities proper in 1963, staff estimates, made in the light of results of earlier university surveys and related materials from university and other sources, placed the total spent for performance of basic research in academic 1963 at around $690 million. Of this, $380 million was estimated as Federal money, $30 million as industrial, $220 million as coming from the educational institutions' own resources, and $60 million as money from nonprofit institutions such as philanthropic foundations and voluntary health agencies.

The committee compares the expenditures estimate of $380 million, which refers generally to academic year 1963, with the obligations figure of "around $600 million" for fiscal year 1965 in "Federal Funds for Research, Development, and Other Scientific Activities, Fiscal Years 1963, 1964, and 1965," volume XIII, and asks, by implication, why there is a "big difference" between the two. As the statistical summary below indicates, the university expenditures of Federal money differ from the Federal obligations for university basic research because the level of obligations has been rising over the years and the expenditures covered in chart 7 took place roughly *2 years before* the cited obligations were made in 1965. (Federal expenditures lag behind obligations and expenditures by recipients throughout the country lag behind Federal expenditures.)

In general, university expenditures of Federal money in a given academic year should be compared with Federal obligations made during the fiscal years which precede and overlap with the academic year. Thus, the $380 million from the 1963 transfer table should be related to the $370 million and $455 million obligated by the Federal agencies in fiscal years 1962 and 1963.

Federal funds for basic research at colleges and universities proper

[In millions]

	1961	1962	1963	1964 [1]	1965 [1]
Federal obligations for basic research at colleges and universities proper [2]	$281	$370	$455	$534	$604
Estimated expenditure of Federal money for basic research at colleges and universities proper [3]		322	380		

[1] Estimated.
[2] Source: "Federal Funds for Research, Development, and Other Scientific Activities," vol. XIII. Updated figures for fiscal years 1964 and 1965 and new data for fiscal year 1966 appear in vol. XIV, now in press, but this table has been based on vol. XIII to retain consistency with data in our July presentation to the committee.
[3] Source: Unpublished NSF staff estimate for 1962; estimate for 1963 from chart 7.

The committee also asks why the fiscal year 1965 figure of "around $600 million" ($604 million in "Federal Funds for Research, Development, and Other Scientific Activities," vol. XIII) for Federal obligations for university basic research is not used, together with "extrapolations [of] some of the other figures to give a more current picture * * *."

One reason why the Federal obligations figure cannot be used as the basis for an extrapolation of chart 7 has already been stated: the transfer table is based on information from performers or doers of research, not from financiers, and the $600 million in obligations is an estimate from the agencies as financiers.

The second reason why extrapolated transfer tables for both research and development and basic research in 1964 have not been published is that we have felt it unwise to publish a current transfer table unless reported data are on hand for at least Federal and industry performance, which together account for over 85 percent of the performance of total research and development. (As indicated earlier, estimates are made for universities and nonprofit institutions for nonsurvey years.) As of July 1965, surveys of both industry and university research and development in 1964 were still out in the field, with preliminary results expected early in the fall 1965; the results of the 1964 survey of other nonprofit organizations are not expected until the spring of 1966. The preliminary results for these two sectors, together with data already on hand for Federal intramural research and development and basic research, will make it possible to publish preliminary 1964 transfer tables for both basic research and research and development by midfall 1965.

In answer to question C–9, which compares data in charts 7 and 8, it is clear from the above discussion that in chart 7 the figure of $1.06 billion represents Federal money actually spent in 1963 throughout the economy in the performance of basic research, as best as we can estimate this from surveys and secondary sources. On the other hand, the Federal totals in chart 8 represent obligations for basic research made by the agencies during a series of fiscal years ending with fiscal year 1965. These obligations found (or will find) their way into actual basic research expenditures by Federal and non-Federal organizations only over a period of years. To clarify this phasing, the summary below compares obligations for the five most recent fiscal years presented in chart 8 with the total of $1.06 billion for 1963 from chart 7.

Total Federal funds for basic research

[In billions]

	1961	1962	1963	1964 [1]	1965 [1]
Federal obligations for basic research—all sectors (chart 8) [2]	$0.80	$1.08	$1.36	$1.63	$1.88
Estimated expenditures of Federal money for basic research—all sectors (chart 7) [3]		.91	1.06		

[1] Estimated.
[2] Source: "Federal funds for Research, Development, and Other Scientific Activities," vol. XIII. Updated figures for fiscal years 1964 and 1965 and new data for fiscal year 1966 appear in vol. XIV, now in press, but this table has been based on vol. XIII to retain consistency with data in our July presention to the committee.
[3] Source: Chart 7 and "Reviews of Data on Science Resources," No. 4.

While no one-to-one relationship can ever be established between the two sets of numbers, it appears, from the table, that the $1.06 billion spent in 1963 by performers of basic research could be traced back, in part, to Federal obligations made in fiscal year 1962 or even earlier, as well as in fiscal year 1963.

In general, the total Federal obligations for basic research, in a given fiscal year, are not likely to be at the same level as actual expenditures for basic research carried on all over the country during about the same period of time, because of the lag in time between Federal obligations and the spending of the funds by recipients. In a period, such as the present, when obligations are rising, expenditures by recipients are likely to lag behind agency obligations.

It is possible to give estimates of the distribution of Federal obligations for basic research in fiscal year 1965 (by performer), basing the estimates on the information for that fiscal year reported by the Federal agencies for the survey which resulted in the publication of "Federal Funds for Research, Development, and Other Scientific Activities," volume XIII, published by NSF last month. The following table summarizes these estimates:

[In millions of dollars]

Performer:	*Estimated obligations*
Federal Government	$361
Industry	423
Universities and colleges:	
Proper	(604)
Federal contract research centers	(293)
Total	897
Other nonprofit institutions	155
Total	[1] 1,836

[1] Excludes $29,400,000 to "foreign" performers and $9,000,000 to "other" performers (primarily individuals).

C–10. Has the Foundation completed or is it engaged in studies as to the absolute or relative amount of Federal support warranted for applied research to meet national needs?

No. The Foundation has neither completed nor is it engaged in studies which deal directly with the question of how much the Federal Government should spend, either in absolute terms or relative to other sources of support, on applied research to meet national needs. However, it should be clear that the Foundation conducts surveys

which provide the basic information on the sources and distribution of expenditures on applied research by the Nation as a whole, as well as by the Federal Government. Moreover, NSF internal staff studies have dealt with a variety of issues which have a direct bearing on the question of the absolute level and relative scale of Federal support of applied research. These studies have dealt with such problems as the bases for differentiating between basic and applied research activities; the relationships between the two; the social and institutional processes involved in their interactions; and research support in the field of engineering. The manpower studies conducted by the Foundation are, of course, also highly relevant to questions concerning the dimensions and character of the support of applied research by the Federal Government.

It may be observed that determining "the absolute or relative amount of Federal support warranted for applied research to meet national needs" is a problem which poses difficulties similar to those identified and discussed in the National Academy of Science report on "Basic Research and National Goals." In fact, the contributions by two members of the Academy's ad hoc panel deal with questions of applied science, and it seems clear that a determination of the "correct" level of support in applied science may be even more difficult than in basic science because the latter can, in considerable measure, be related to needs in graduate education.

C–11. How are research grants audited by NSF?

C–12. Could another agency of the Government, such as DOD or NASA, provide audit services for NSF at institutions where both have grants?

The audit of NSF research grants, which is not conducted on all Foundation grants but is limited to a sample of these, encompasses three phases, each of which is accomplished by the Foundation's auditors using a specific audit program which is modified as appropriate.

The first phase of the audit includes (1) a review of background information concerning the grants and grantee organizations, (2) a determination that the grants have been processed in accordance with prescribed administrative procedures, (3) a determination as to the funding that has been provided, and (4) a determination whether required financial reporting on each grant has been received from the grantees and whether the reports received are adequate.

The second phase of the audit of research grants involves an on-site review. At this time, an evaluation is made as to the adequacy of the grantee's accounting and administrative procedures insofar as they pertain to NSF grant activities, including, on a selective test basis, the examination of direct costs incurred for the grants. Also, the auditors determine whether there has been (1) consistency in the grantee's accounting distribution of charges between the direct and indirect cost categories and (2) compliance with conditions of the grants. For the academic institutions, the NSF auditors ascertain whether the institution's indirect cost rate(s), as determined by a cognizant audit agency, is in excess of the maximum rate allowed by the Foundation. In addition, for grantees other than academic institutions, the NSF auditors determine the indirect cost rates applicable to the grants.

The final phase of the audit entails a review of the audit findings with the grantee and the Foundation's program and administrative

personnel. This review is to resolve all problems of an audit nature, and to develop recommendations to management which are included in the audit reports.

We believe that an agency, such as DOD or NASA, could provide audit services for NSF with respect to the determination of an institution's *indirect* cost rate which would be applicable to NSF grants. The development of indirect cost rates is based upon established cost principles used throughout the Government, and familiarity with the Foundation's programs would be secondary. It is a matter of Foundation policy to accept the indirect cost determination of any other Federal agency without further review.

The audit of *direct* costs charged to grants poses an entirely different situation, and it is doubtful that another agency of the Government could provide audit services for NSF. To perform an effective audit of NSF grants, the auditors must be fully conversant with the Foundation's programs including background information on practices, procedures, philosophy, and requirements of the grants. Before an on-site audit, the auditors must review the background material with the program staff and grants administration personnel. Further, it is necessary upon completion of the on-site audit for the auditors to review the findings with the program offices and the grants administration personnel before the audit report is prepared.

In view of the above, NSF believes it would be difficult for such agencies as DOD or NASA to provide audit services with respect to the *direct* costs incurred for NSF grants. Given time, it might be possible for auditors employed by such agencies as DOD or NASA to become sufficiently familiar with NSF programs to provide adequate audit services, but there is little reason to think that this would result in overall efficiency in the auditing of NSF grants—and there probably would be a number of problems created under such a system.

D. Support of Research Facilities

D–1. Has the support of research facilities in eductional institutions by the Foundation resulted in artificial and unwanted movement of competent researchers from their original institution?

The increased emphasis on science and the rapid rate of increase in enrollment in institutions of higher education have created a demand for scientific faculty of high quality which overreaches the supply in many fields. This situation of high demand and low supply has resulted in an increasing mobility of competent university scientists.

Several factors contribute to this mobility, only one of which relates to facilities.

1. University salaries have been increasing significantly. But because these increases are not uniform among the various institutions and the differentials are substantial, certain schools are able to attract to their campuses experienced faculty from other institutions. This phenomenon is by no means a new one. What *is* new is the large number of "rising" institutions that can now compete with the older "top-salary" universities.

2. Research has become more complex, more interdisciplinary, and more expensive. Institutions with recognized scientific strength and administrative foresight are competing more favorably in attracting competent scientists.

3. Scientists generally agree that research is a necessary part of academic activity if a faculty member is to keep abreast of current developments in his field and do a creditable job of teaching. They continually work to attain or maintain teaching loads at a level which will permit a reasonable balance between formal instruction and research, which usually includes the training of graduate students. Institutions which have arrived at such a balance are better able to attract competent scientific faculty.

4. Facilities are also a significant part of an institution's capability for recruiting or retaining faculty. Other factors being equal, a competent scientist might well move to another institution which had markedly superior research facilities, especially major technical ones, such as particle accelerators and special biological facilities.

It can be concluded, therefore, that any funds awarded from Federal sources for research facilities may have an influence on the movement of competent scientists by affecting any or all of the points discussed. Not only will such financial assistance aid the recipient institution to acquire more and better research equipment and space, but university funds may be released for salaries, for incremental faculty (which may in turn spread teaching loads), and for other direct research costs.

Facilities grants made by the National Science Foundation are based on scientific merit and the indicated ability of the recipient institutions to retain or improve their achieved degree of scientific

excellence. Thus, improved and expanded facilities acquired with the assistance of NSF funds enable the recipient institutions both to retain their competent scientists and to augment their staffs. Limited movement of competent scientists as a result of NSF research facilities grants is not undesirable, particularly when it helps strengthen institutions on the way "up."

It is worthy of note that the Foundation's contribution to the total amount estimated to have been spent for additions to physical plant at colleges and universities in academic year 1963–64 is approximately 2.9 percent.[1] In view of this, it is clear that the Foundation in its support of facilities has not significantly affected staffing patterns at institutions of higher education.

D–2. How has the geographical distribution of NSF support for research facilities differed from that of the other Federal agencies over the last 15 years?

Foundation activities which provide support for research facilities have been in existence for a period of about 6 years. These activities consist principally of two programs: (*a*) The specialized facilities program of the Research Division, and (*b*) The graduate-level science facilities program of the Institutional Programs Division.

The most recent and best information available on the geographical distribution of these facilities funds is available in a recent Foundation report.[2] These data, which cover fiscal years 1961–64, have been reproduced and appear on the following pages.

R. & D. plant obligations at educational institutions, by geographic divisions and States, by selected agencies

FISCAL YEAR 1961

[In thousands of dollars]

Location	Federal total	Agriculture	Commerce	Defense	HEW	Interior	AEC	NASA	NSF
NEW ENGLAND									
Maine	6				6				
Vermont	708				708				
Massachusetts	11,074			5,070	1,843		2,156		2,005
Rhode Island	131				123				8
Connecticut	477				220				257
Subtotal	12,396			5,070	2,900		2,156		2,270
MIDDLE ATLANTIC									
New York	6,421				4,433		1,040		948
New Jersey	5,473				261		4,705		507
Pennsylvania	1,715				1,198		80		437
Subtotal	13,609				5,892		5,825		1,892

[1] Based on Foundation obligations for science facilities in fiscal year 1964 of about $50 million and an estimate of $1.7 billion for additions to physical plant at colleges and universities in 1963–64: "Projections of Educational Statistics to 1973–74," HEW Publication No. OE–10030, 1964.

[2] "Obligations for Research and Development, and R. & D. Plant, by Geographic Divisions and States, by Selected Federal Agencies, Fiscal Years 1961–64": A report to the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, of data derived from a survey conducted by the National Science Foundation, April–July 1964, pt. I, consolidated totals, pp. 240–255.

R. & D. plant obligations at educational institutions, by geographic divisions and States, by selected agencies—Continued

FISCAL YEAR 1961—Continued

[In thousands of dollars]

Location	Federal total	Agriculture	Commerce	Defense	HEW	Interior	AEC	NASA	NSF
EAST NORTH CENTRAL									
Ohio	493	--------	--------	--------	429	--------	19	--------	45
Indiana	1,087	--------	--------	--------	538	--------	233	--------	316
Illinois	1,665	--------	--------	--------	1,179	--------	298	--------	188
Michigan	340	--------	--------	--------	--------	--------	239	--------	101
Wisconsin	4,273	--------	--------	--------	3,636	--------	126	--------	511
Subtotal	7,858	--------	--------	--------	5,782	--------	915	--------	1,161
WEST NORTH CENTRAL									
Minnesota	161	--------	--------	--------	83	--------	27	--------	51
Iowa	5,215	--------	--------	--------	347	--------	4,732	--------	136
Missouri	50	--------	--------	--------	50	--------	--------	--------	--------
North Dakota	6	--------	--------	--------	6	--------	--------	--------	--------
South Dakota	10	--------	--------	--------	10	--------	--------	--------	--------
Nebraska	755	--------	--------	--------	755	--------	--------	--------	--------
Kansas	176	--------	--------	--------	68	--------	51	--------	57
Subtotal	6,373	--------	--------	--------	1,319	--------	4,810	--------	244
SOUTH ATLANTIC									
Maryland	1,374	--------	--------	--------	1,080	--------	37	--------	257
District of Columbia	628	--------	--------	--------	--------	--------	--------	--------	628
Virginia	1,633	--------	--------	--------	1,633	--------	--------	--------	--------
North Carolina	1,824	--------	--------	--------	1,216	--------	--------	--------	608
South Carolina	498	--------	--------	--------	498	--------	--------	--------	--------
Georgia	127	--------	--------	--------	20	--------	35	--------	72
Florida	864	--------	--------	--------	550	--------	75	--------	239
Subtotal	6,948	--------	--------	--------	4,997	--------	147	--------	1,804
EAST SOUTH CENTRAL									
Kentucky	235	--------	--------	--------	229	--------	--------	--------	6
Tennessee	69	--------	--------	--------	--------	--------	--------	--------	69
Mississippi	1,463	--------	--------	--------	1,463	--------	--------	--------	--------
Subtotal	1,767	--------	--------	--------	1,692	--------	--------	--------	75
WEST SOUTH CENTRAL									
Louisiana	162	--------	--------	--------	143	--------	--------	--------	19
Oklahoma	83	--------	--------	--------	83	--------	--------	--------	--------
Texas	1,159	--------	--------	--------	766	--------	--------	--------	393
Subtotal	1,404	--------	--------	--------	992	--------	--------	--------	412
MOUNTAIN									
Colorado	1,719	--------	--------	--------	1,337	--------	296	--------	86
New Mexico	152	--------	--------	--------	--------	--------	--------	--------	152
Arizona	519	--------	--------	--------	323	--------	--------	--------	196
Utah	512	--------	--------	--------	449	--------	46	--------	17
Nevada	57	--------	--------	--------	57	--------	--------	--------	--------
Subtotal	2,959	--------	--------	--------	2,166	--------	342	--------	451
PACIFIC									
Washington	1,374	--------	--------	--------	1,111	--------	--------	--------	263
Oregon	480	350	--------	--------	--------	--------	--------	--------	130
California	11,585	--------	--------	--------	1,382	--------	8,296	500	1,407
Alaska	13	--------	--------	--------	--------	--------	--------	--------	13
Hawaii	551	--------	--------	--------	243	--------	--------	--------	308
Subtotal	14,003	350	--------	--------	2,736	--------	8,296	500	2,121
Total	67,317	350	--------	5,070	28,476	--------	22,491	500	10,430

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

PERCENT DISTRIBUTION, FISCAL YEAR 1961

Location	Total, all agencies	Agriculture		Commerce		Defense		HEW		Interior		AEC		NASA		NSF	
		Percent of Federal total	Percent of Agriculture total	Percent of Federal total	Percent of Commerce total	Percent of Federal total	Percent of Defense total	Percent of Federal total	Percent of HEW total	Percent of Federal total	Percent of Interior total	Percent of Federal total	Percent of AEC total	Percent of Federal total	Percent of NASA total	Percent of Federal total	Percent of NSF total
NEW ENGLAND																	
Maine	(1)							(1)	(1)								
Vermont	1.1							1.1	2.5								
Massachusetts	16.5					7.5	100.0	2.7	6.5			3.2	9.6			3.0	19.2
Rhode Island	.2							.2	.4							(1)	.1
Connecticut	.7							.3	.8							.4	2.5
Subtotal	18.4					7.5	100.0	4.3	10.2			3.2	9.6			3.4	21.8
MIDDLE ATLANTIC																	
New York	9.5							6.6	15.6			1.5	4.6			1.4	9.1
New Jersey	8.1							.4	.9			7.0	20.9			.8	4.9
Pennsylvania	2.5							1.8	4.2			.1	.4			.6	4.2
Subtotal	20.2							8.8	20.7			8.7	25.9			2.8	18.1
EAST NORTH CENTRAL																	
Ohio	.7							.6	1.5			(1)	.1			.1	.4
Indiana	1.6							.8	1.9			.3	1.0			.5	3.0
Illinois	2.5							1.8	4.1			.4	1.3			.3	1.8
Michigan	.5											.4	1.1			.2	1.0
Wisconsin	6.3							5.4	12.8			.2	.6			.8	4.9
Subtotal	11.7							8.6	20.3			1.4	4.1			1.7	11.1
WEST NORTH CENTAL																	
Minnesota	.2							.1	.3			(1)	.1			.1	.5
Iowa	7.7							.5	1.2			7.0	21.0			.2	1.3
Missouri	.1							.1	.2								
North Dakota	(1)							(1)	(1)								
South Dakota	(1)							(1)	(1)								
Nebraska	1.1							1.1	2.7								
Kansas	.3							.1	.2			.1	.2			.1	.5
Subtotal	9.5							2.0	4.6			7.1	21.4			.4	2.3

SOUTH ATLANTIC																	
Maryland	2.0							1.6	3.8			.1	.2			.4	2.5
District of Columbia	.9															.9	6.0
Virginia	2.4							2.4	5.7								
North Carolina	2.7							1.8	4.3								
South Carolina	.7							.7	1.7							.9	5.8
Georgia	.2							(1)	.1			.1	.2			.1	.7
Florida	1.3							.8	1.9			.1	.3			.4	2.3
Subtotal	10.3							7.4	17.5			.2	.7			2.7	17.3
EAST SOUTH CENTRAL																	
Kentucky	.3							.3	.8							(1)	.1
Tennessee	.1															.1	.7
Mississippi	2.2							2.2	5.1								
Subtotal	2.6							2.5	5.9							.1	.7
WEST SOUTH CENTRAL																	
Louisiana	.2							.2	.5							(1)	.2
Oklahoma	.1							.1	.1								
Texas	1.7							1.1	2.7							.6	3.8
Subtotal	2.1							1.5	3.5							.6	4.0
MOUNTAIN																	
Colorado	2.6							2.0	4.7			.4	1.3			.1	.8
New Mexico	.2															.2	1.5
Arizona	.8							.5	1.1							.3	1.9
Utah	.8							.7	1.6			.1	.2			(1)	.2
Nevada	.1							.1	.2								
Subtotal	4.4							3.2	7.6			.5	1.5			.7	4.3
PACIFIC																	
Washington	2.0							1.7	3.9							.4	2.5
Oregon	.7	0.5	100.0													.2	1.2
California	17.2							2.1	4.9			12.3	36.9	0.7	100.0	2.1	13.5
Alaska	(1)															(1)	.1
Hawaii	.8							.4	.9							.5	3.0
Subtotal	20.8	.5	100.0					4.1	9.6			12.3	36.9	.7	100.0	3.2	20.3
Total	100.0	.5	100.0			7.5	100.0	42.3	100.0			33.4	100.0	.7	100.0	15.5	100.0

[1] Less than 1/10 of 1 percent. Percentages may not add to total because of rounding.

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

FISCAL YEAR 1962

[In thousands of dollars]

Location	Federal total	Agriculture	Commerce	Defense	HEW	Interior	AEC	NASA	NSF
NEW ENGLAND									
Maine	114								114
New Hampshire	90				41				49
Vermont	35								35
Massachusetts	8,949				689		3,282		4,978
Rhode Island	634				390		47		197
Connecticut	335						286		49
Subtotal	10,157				1,120		3,615		5,422
MIDDLE ATLANTIC									
New York	11,854				8,218		525	1,500	1,611
New Jersey	6,094				133		3,400		2,561
Pennsylvania	3,669				1,016		134		2,519
Subtotal	21,617				9,367		4,059	1,500	6,691
EAST NORTH CENTRAL									
Ohio	1,188				535		42		611
Indiana	1,931				26		1,732		173
Illinois	5,446				1,266		269	1,775	2,136
Michigan	3,937				890		221		2,826
Wisconsin	991				149		48		794
Subtotal	13,493				2,866		2,312	1,775	6,540
WEST NORTH CENTRAL									
Minnesota	2,220	1,265			453		16		486
Iowa	3,297				823		1,042	634	798
Missouri	1,019				176				843
North Dakota	615	130			452				33
Nebraska	1,059				586				473
Kansas	426				97		11		318
Subtotal	8,636	1,395			2,587		1,069	634	2,951
SOUTH ATLANTIC									
Delaware	255						22		233
Maryland	1,866				605		14		1,247
District of Columbia	49								49
Virginia	765				310		4		451
West Virginia	14								14
North Carolina	1,125				289		36		800
South Carolina	29								29
Georgia	1,046	583			277		2		184
Florida	947				205		100		642
Subtotal	6,096	583			1,686		178		3,649

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

FISCAL YEAR 1962—Continued

[In thousands of dollars]

Location	Federal total	Agriculture	Commerce	Defense	HEW	Interior	AEC	NASA	NSF
EAST SOUTH CENTRAL									
Tennessee	1,456				883				573
Alabama	145				130				15
Mississippi	383				383				
Subtotal	1,984				1,396				588
WEST SOUTH CENTRAL									
Arkansas	5								5
Louisiana	1,508				1,475				33
Oklahoma	211								211
Texas	2,911				1,736		48		1,127
Subtotal	4,635				3,211		48		1,376
MOUNTAIN									
Montana	194	175							19
Idaho	306	300							6
Wyoming	152	150							2
Colorado	983				428		235		320
New Mexico	9								9
Arizona	355	150							205
Utah	653				259		92		302
Subtotal	2,652	775			687		327		863
PACIFIC									
Washington	1,479				8				1,471
Oregon	670						12		658
California	34,987				4,295		25,857		4,835
Alaska	423	345							78
Hawaii	2,642								2,642
Subtotal	40,201	345			4,303		25,869		9,684
Total	109,471	3,098			27,223		37,477	3,909	37,764

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

PERCENT DISTRIBUTION, FISCAL YEAR 1962

Location	Total, all agencies	Agriculture		Commerce		Defense		HEW		Interior		AEC		NASA		NSF	
		Percent of Federal total	Percent of Agriculture total	Percent of Federal total	Percent of Commerce total	Percent of Federal total	Percent of Defense total	Percent of Federal total	Percent of HEW total	Percent of Federal total	Percent of Interior total	Percent of Federal total	Percent of AEC total	Percent of Federal total	Percent of NASA total	Percent of Federal total	Percent of NSF total
NEW ENGLAND																	
Maine	0.1															0.1	0.3
New Hampshire	.1							(1)	0.2							(1)	.1
Vermont	(1)															(1)	.1
Massachusetts	8.2							0.6	2.5			3.0	8.8			4.5	13.2
Rhode Island	.6							.4	1.4			(1)	.1			.2	.5
Connecticut	.3											.3	.8			(1)	.1
Subtotal	9.3							1.0	4.1			3.3	9.6			5.0	14.4
MIDDLE ATLANTIC																	
New York	10.8							7.5	30.2			.5	1.4	1.4	38.4	1.5	4.3
New Jersey	5.6							.1	.5			3.1	9.1			2.3	6.8
Pennsylvania	3.4							.9	3.7			.1	.4			2.3	6.7
Subtotal	19.7							8.6	34.4			3.7	10.8	1.4	38.4	6.1	17.7
EAST NORTH CENTRAL																	
Ohio	1.1							.5	2.0			(1)	.1			.6	1.6
Indiana	1.8							(1)	.1			1.6	4.6			.2	.5
Illinois	5.0							1.2	4.7			.2	.7	1.6	45.4	2.0	5.7
Michigan	3.6							.8	3.3			.2	.6			2.6	7.5
Wisconsin	.9							.1	.5			(1)	.1			.7	2.1
Subtotal	12.3							2.6	10.5			2.1	6.2	1.6	45.4	6.0	17.3
WEST NORTH CENTRAL																	
Minnesota	2.0	1.2	40.8					.4	1.7			(1)	(1)			.4	1.3
Iowa	3.0							.8	3.0			1.0	2.8	.6	16.2	.7	2.1
Missouri	.9							.2	.6							.8	2.2
North Dakota	.6	.1	4.2					.4	1.7							(1)	.1
Nebraska	1.0							.5	2.2							.4	1.3
Kansas	.4							.1	.4			(1)	(1)			.3	.8
Subtotal	7.9	1.3	45.0					2.4	9.5			1.0	2.9	.6	16.2	2.7	7.8

SOUTH ATLANTIC																	
Delaware	.2											(1)	.1			.2	.6
Maryland	1.7							.6	2.2			(1)	(1)			1.1	3.3
District of Columbia	(1)															(1)	.1
Virginia	.7							.3	1.1			(1)	(1)			.4	1.2
West Virginia	(1)															(1)	(1)
North Carolina	1.0							.3	1.1			(1)	.1			.7	2.1
South Carolina	(1)															(1)	.1
Georgia	1.0	.5	18.8					.3	1.0			(1)	(1)			.2	.5
Florida	.9							.2	.8			.1	.3			.6	1.7
Subtotal	5.6	.5	18.8					1.5	6.2			.2	.5			3.3	9.7
EAST SOUTH CENTRAL																	
Tennessee	1.3							.8	3.2							.5	1.5
Alabama	.1							.1	.5							(1)	(1)
Mississippi	.3							.3	1.4								
Subtotal	1.8							1.3	5.1							.5	1.6
WEST SOUTH CENTRAL																	
Arkansas	(1)															(1)	(1)
Louisiana	1.4							1.3	5.4							(1)	.1
Oklahoma	.2															.2	.6
Texas	2.7							1.6	6.4			(1)	.1			1.0	3.0
Subtotal	4.2							2.9	11.8			(1)	.1			1.3	3.6
MOUNTAIN																	
Montana	.2	.2	5.6													(1)	.1
Idaho	.3	.3	9.7													(1)	(1)
Wyoming	.1	.1	4.8													(1)	(1)
Colorado	.9							.4	1.6			.2	.6			.3	.8
New Mexico	(1)															(1)	(1)
Arizona	.3	.1	4.8													.2	.5
Utah	.6							.2	1.0			.1	.2			.3	.8
Subtotal	2.4	.7	25.0					.6	2.5			.3	.9			.8	2.3
PACIFIC																	
Washington	1.4							(1)	(1)							1.3	3.9
Oregon	.6											(1)	(1)			.6	1.7
California	32.0							3.9	15.8			23.6	69.0			4.4	12.8
Alaska	.4	.3	11.1													.1	.2
Hawaii	2.4															2.4	7.0
Subtotal	36.7	.3	11.1					3.9	15.8			23.6	69.0			8.8	25.6
Total	100.0	2.8	100.0					24.9	100.0			34.2	100.0	3.6	100.0	34.5	100.0

1 Less than 1/10 of 1 percent. Percentages may not add to total because of rounding.

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

FISCAL YEAR 1963

[In thousands of dollars]

Location	Federal total	Agriculture	Commerce	Defense	HEW	Interior	AEC	NASA	NSF
NEW ENGLAND									
Maine	99				47				52
New Hampshire	775								775
Massachusetts	11,389				3,101		3,791	2,782	1,715
Rhode Island	809				185				624
Connecticut	3,376				2,669		44		663
Subtotal	16,448				6,002		3,835	2,782	3,829
MIDDLE ATLANTIC									
New York	9,728				2,524		761		6,443
New Jersey	9,170				610		6,694	580	1,286
Pennsylvania	5,415				2,315		8	1,391	1,701
Subtotal	24,313				5,449		7,463	1,971	9,430
EAST NORTH CENTRAL									
Ohio	1,130				265		40		825
Indiana	1,355				159		259		937
Illinois	8,849				3,323		1,007		4,519
Michigan	9,130				5,105		225	1,623	2,177
Wisconsin	3,818				1,931			411	1,476
Subtotal	24,282				10,783		1,531	2,034	9,934
WEST NORTH CENTRAL									
Minnesota	1,763				118		211	653	781
Iowa	3,550				287		1,230		2,033
Missouri	2,225				1,658				567
North Dakota	251				169				82
South Dakota	106				50				56
Nebraska	49				49				
Kansas	23								23
Subtotal	7,967				2,331		1,441	653	3,542
SOUTH ATLANTIC									
Delaware	464				298				166
Maryland	1,869				429		13		1,427
District of Columbia	281						14		267
Virginia	741				135				606
West Virginia	12								12
North Carolina	1,050				271		35		744
South Carolina	53				53				
Georgia	2,126	250			1,788				88
Florida	1,491				497		203		791
Subtotal	8,087	250			3,471		265		4,101

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

FISCAL YEAR 1963—Continued

[In thousands of dollars]

Location	Federal total	Agriculture	Commerce	Defense	HEW	Interior	AEC	NASA	NSF
EAST SOUTH CENTRAL									
Kentucky	26								26
Tennessee	1,890				1,390		4		496
Alabama	152				138				14
Mississippi	81								81
Subtotal	2,149				1,528		4		617
WEST SOUTH CENTRAL									
Arkansas	328				150				178
Louisiana	2,072				2,041				31
Oklahoma	2,194				1,287				907
Texas	830				270		36		524
Subtotal	5,424				3,748		36		1,640
MOUNTAIN									
Montana	69				69				
Colorado	1,834				562		89	735	448
New Mexico	7								7
Arizona	1,021	466			29			219	307
Utah	1,370	283			814		57		216
Subtotal	4,301	749			1,474		146	954	978
PACIFIC									
Washington	3,469				96				3,373
Oregon	1,748	130			567				1,051
California	59,323				4,560		48,690	1,855	4,218
Alaska	7	7							
Hawaii	291								291
Subtotal	64,838	137			5,223		48,690	1,855	8,933
Territories	121						101		20
Total	157,930	1,136			40,009		63,512	10,249	43,024

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

PERCENT DISTRIBUTION, FISCAL YEAR 1963

Location	Total, all agencies	Agriculture		Commerce		Defense		HEW		Interior		AEC		NASA		NSF	
		Percent of Federal total	Percent of Agriculture total	Percent of Federal total	Percent of Commerce total	Percent of Federal total	Percent of Defense total	Percent of Federal total	Percent of HEW total	Percent of Federal total	Percent of Interior total	Percent of Federal total	Percent of AEC total	Percent of Federal total	Percent of NASA total	Percent of Federal total	Percent of NSF total
NEW ENGLAND																	
Maine	0.1							[1]	0.1							[1]	0.1
New Hampshire	.5															0.5	1.8
Massachusetts	7.2							2.0	7.8			2.4	6.0	1.8	27.1	1.1	4.0
Rhode Island	.5							.1	.5							.4	1.5
Connecticut	2.1							1.7	6.7			[1]	.1			.4	1.5
Subtotal	10.4							3.8	15.0			2.4	6.0	1.8	27.1	2.4	8.9
MIDDLE ATLANTIC																	
New York	6.2							1.6	6.3			.5	1.2			4.1	15.0
New Jersey	5.8							.4	1.5			4.2	10.5	.4	5.7	.8	3.0
Pennsylvania	3.4							1.5	5.8			[1]	[1]	.9	13.6	1.1	4.0
Subtotal	15.4							3.5	13.6			4.7	11.8	1.2	19.2	6.0	21.9
EAST NORTH CENTRAL																	
Ohio	.7							.2	.7			[1]	.1			.5	1.9
Indiana	.9							.1	.4			.2	.4			.6	2.2
Illinois	5.6							2.1	8.3			.6	1.6			2.9	10.5
Michigan	5.8							3.2	12.8			.1	.4	1.0	15.8	1.4	5.1
Wisconsin	2.4							1.2	4.8					.3	4.0	.9	3.4
Subtotal	15.4							6.8	27.0			1.0	2.4	1.3	19.8	6.3	23.1
WEST NORTH CENTRAL																	
Minnesota	1.1							.1	.3			.1	.3	.4	6.4	.5	1.8
Iowa	2.2							.2	.7			.8	1.9			1.3	4.7
Missouri	1.4							1.0	4.1							.4	1.3
North Dakota	.2							.1	.4							.1	.2
South Dakota	.1							[1]	.1							[1]	.1
Nebraska	[1]							[1]	.1								
Kansas	[1]															[1]	.1
Subtotal	5.0							1.5	5.8			.9	2.3	.4	6.4	2.2	8.2

SOUTH ATLANTIC																	
Delaware	.3							.2	.7							.1	.4
Maryland	1.2							.3	1.1			(1)	(1)			.9	3.3
District of Columbia	.2											(1)	(1)			.2	.6
Virginia	.5							.1	.3							.4	1.4
West Virginia	(1)															(1)	(1)
North Carolina	.7							.2	.7			(1)	.1			.5	1.7
South Carolina	(1)							(1)	.1								
Georgia	1.3	0.2	22.0					1.1	4.5							.1	.2
Florida	.9							.3	1.2			.1	.3			.5	1.8
Subtotal	5.1	.2	22.0					2.2	8.7			.2	.4			2.6	9.5
EAST SOUTH CENTRAL																	
Kentucky	(1)															(1)	.1
Tennessee	1.2							.9	3.5			(1)	(1)			.3	1.2
Alabama	.1							.1	.3							(1)	(1)
Mississippi	.1															.1	.2
Subtotal	1.4							1.0	3.8			(1)	(1)			.4	1.4
WEST SOUTH CENTRAL																	
Arkansas	.2							.1	.4							.1	.4
Louisiana	1.3							1.3	5.1							(1)	.1
Oklahoma	1.4							.8	3.2							.6	2.1
Texas	.5							.2	.7			(1)	.1			.3	1.2
Subtotal	3.4							2.4	9.4			(1)	.1			1.0	3.8
MOUNTAIN																	
Montana	(1)							(1)	.2								
Colorado	1.2							.4	1.4			.1	.1	.5	7.2	.3	1.0
New Mexico	(1)															(1)	(1)
Arizona	.6	.3	41.0					(1)	.1					.1	2.1	.2	.7
Utah	.9	.2	24.9					.5	2.0			(1)	.1			.1	.5
Subtotal	2.7	.5	65.9					.9	3.7			.1	.2	.6	9.3	.6	2.3
PACIFIC																	
Washington	2.2							.1	.2							2.1	7.8
Oregon	1.1	.1	11.4					.4	1.4							.7	2.4
California	37.6							2.9	11.4			30.8	76.7	1.2	18.1	2.7	9.8
Alaska	(1)	(1)	.6														
Hawaii	.2															.2	.7
Subtotal	41.1	.1	12.1					3.3	13.1			30.8	76.7	1.2	18.1	5.7	20.8
Territories	.1											.1	.2			(1)	(1)
Total	100.0	.7	100.0					25.3	100.0			40.2	100.0	6.5	100.0	27.2	100.0

[1] Less than 1/10 of 1 percent. Percentages may not add to total because of rounding.

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

FISCAL YEAR 1964

[In thousands of dollars]

Location	Federal total	Agriculture	Commerce	Defense	HEW	Interior	AEC	NASA	NSF
NEW ENGLAND									
Maine	25								25
New Hampshire	258								258
Vermont	102								102
Massachusetts	7,932				1,371		2,536		4,025
Rhode Island	754				385				369
Connecticut	5,645				3,592		865		1,188
Subtotal	14,716				5,348		3,401		5,967
MIDDLE ATLANTIC									
New York	10,294				3,883		595	1,000	4,816
New Jersey	8,618						7,438		1,180
Pennsylvania	3,159				625	30	100		2,404
Subtotal	22,071				4,508	30	8,133	1,000	8,400
EAST NORTH CENTRAL									
Ohio	1,465				257				1,208
Indiana	2,130							840	1,290
Illinois	6,776				2,981		605		3,190
Michigan	2,768	28			598		303		1,839
Wisconsin	2,172				1,000				1,172
Subtotal	15,311	28			4,836		908	840	8,699
WEST NORTH CENTRAL									
Minnesota	1,556				294		480		782
Iowa	2,525						2,193		332
Missouri	1,862				595			600	667
North Dakota	33								33
South Dakota	25								25
Nebraska	172								172
Kansas	595				189				406
Subtotal	6,768				1,078		2,673	600	2,417
SOUTH ATLANTIC									
Delaware	86								86
Maryland	3,478				1,064		5	1,500	889
District of Columbia	473				121				352
Virginia	246				29				217
West Virginia	124	32				10			82
North Carolina	5,237				4,510		101		626
South Carolina	78								78
Georgia	1,221							1,000	221
Florida	921				29				892
Subtotal	11,864	32			5,773	10	106	2,500	3,443

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

FISCAL YEAR 1964—Continued

[In thousands of dollars]

Location	Federal total	Agri-culture	Com-merce	Defense	HEW	Interior	AEC	NASA	NSF
EAST SOUTH CENTRAL									
Kentucky	294				114				180
Tennessee	248	18							230
Alabama	45								45
Mississippi	45								45
Subtotal	632	18			114				500
WEST SOUTH CENTRAL									
Arkansas	66								66
Louisiana	512				159				353
Oklahoma	286				15				271
Texas	4,814				513		579	2,600	1,122
Subtotal	5,678				687		579	2,600	1,812
MOUNTAIN									
Montana	85	28							57
Idaho	61								61
Wyoming	29								29
Colorado	779	79					127		573
New Mexico	135								135
Arizona	623							206	417
Utah	901				503	20	95		283
Nevada	45								45
Subtotal	2,658	107			503	20	222	206	1,600
PACIFIC									
Washington	3,589				2,680				909
Oregon	499								499
California	65,214				5,402		53,498	160	6,154
Alaska	746				500				246
Hawaii	279								279
Subtotal	70,327				8,582		53,498	160	8,087
Territories	41						16		25
Unallocated	11,115				7,021			4,094	
Total	161,181	185			38,450	60	69,536	12,000	40,950

R. & D. plant obligations at educational institutions, by geographic divisions and States—Continued

PERCENT DISTRIBUTION, FISCAL YEAR 1964

Location	Total, all agencies	Agriculture		Commerce		Defense		HEW		Interior		AEC		NASA		NSF	
		Percent of Federal total	Percent of Agriculture total	Percent of Federal total	Percent of Commerce total	Percent of Federal total	Percent of Defense total	Percent of Federal total	Percent of HEW total	Percent of Federal total	Percent of Interior total	Percent of Federal total	Percent of AEC total	Percent of Federal total	Percent of NASA total	Percent of Federal total	Percent of NSF total
NEW ENGLAND																	
Maine	(1)															(1)	0.1
New Hampshire	0.2															0.2	.6
Vermont	.1															.1	.2
Massachusetts	4.9							0.9	3.6			1.6	3.6			2.5	9.8
Rhode Island	.5							.2	1.0							.2	.9
Connecticut	3.5							2.2	9.3			.5	1.2			.7	2.9
Subtotal	9.1							3.3	13.9			2.1	4.9			3.7	14.6
MIDDLE ATLANTIC																	
New York	6.4							2.4	10.1			.4	.9	0.6	8.3	3.0	11.8
New Jersey	5.3											4.6	10.7			.7	2.9
Pennsylvania	2.0							.4	1.6	(1)	50.0	.1	.1			1.5	5.9
Subtotal	13.7							2.8	11.7	(1)	50.0	5.0	11.7	.6	8.3	5.2	20.5
EAST NORTH CENTRAL																	
Ohio	.9							.2	.7							.7	2.9
Indiana	1.3													.5	7.0	.8	3.2
Illinois	4.2							1.8	7.8			.4	.9			2.0	7.8
Michigan	1.7	(1)	15.1					.4	1.6			.2	.4			1.1	4.5
Wisconsin	1.3							.6	2.6							.7	2.9
Subtotal	9.5	(1)	15.1					3.0	12.6			.6	1.3	.5	7.0	5.4	21.2
WEST NORTH CENTRAL																	
Minnesota	1.0							.2	.8			.3	.7			.5	1.9
Iowa	1.6											1.4	3.2			.2	.8
Missouri	1.2							.4	1.5					.4	5.0	.4	1.6
North Dakota	(1)															(1)	.1
South Dakota	(1)															(1)	.1
Nebraska	.1															.1	.4
Kansas	.4							.1	.5							.3	1.0
Subtotal	4.2							.7	2.8			1.7	3.8	.4	5.0	1.5	5.9
SOUTH ATLANTIC																	
Delaware	.1															.1	.2

Maryland	2.2							.7	2.8			(1)	(1)	.9	12.5	.6	2.2
District of Columbia	.3							.1	.3							.2	.9
Virginia	.2							(1)	.1							.1	.5
West Virginia	.1	(1)	17.3							(1)	16.7					.1	.2
North Carolina	3.2							2.8	11.7			.1	.1			.4	1.5
South Carolina	(1)															(1)	.2
Georgia	.8													.6	8.3	.1	.5
Florida	.6							(1)	.1							.6	2.2
Subtotal	7.4	(1)	17.3					3.6	15.0	(1)	16.7	.1	.2	1.6	20.8	2.1	8.4
EAST SOUTH CENTRAL																	
Kentucky	.2							.1	.3							.1	.4
Tennessee	.2	(1)	9.7													.1	.6
Alabama	(1)															(1)	.1
Mississippi	(1)															(1)	.1
Subtotal	.4	(1)	9.7					.1	.3							.3	1.2
WEST SOUTH CENTRAL																	
Arkansas	(1)															(1)	.2
Louisiana	.3							.1	.4							.2	.9
Oklahoma	.2							(1)	(1)							.2	.7
Texas	3.0							.3	1.3			.4	.8	1.6	21.7	.7	2.7
Subtotal	3.5							.4	1.8			.4	.8	1.6	21.7	1.1	4.4
MOUNTAIN																	
Montana	.1	(1)	15.1													(1)	.1
Idaho	(1)															(1)	.1
Wyoming	(1)															(1)	.1
Colorado	.5	(1)	42.7									.1	.2			.4	1.4
New Mexico	.1															.1	.3
Arizona	.4													.1	1.7	.3	1.0
Utah	.6							.3	1.3	(1)	33.3	.1	.1			.2	.7
Nevada	(1)															(1)	.1
Subtotal	1.6	0.1	57.8					.3	1.3	(1)	33.3	.1	.3	.1	1.7	1.0	3.9
PACIFIC																	
Washington	2.2							1.7	7.0							.6	2.2
Oregon	.3															.3	1.2
California	40.5							3.4	14.0			33.2	76.9	.1	1.3	3.8	15.0
Alaska	.5							.3	1.3							.2	.6
Hawaii	.2															.2	.7
Subtotal	43.6							5.3	22.3			33.2	76.9	.1	1.3	5.0	19.7
Territories	(1)											(1)	(1)			(1)	.1
Unallocated	6.9							4.4	18.3					2.5	34.1		
Total	100.0	.1	100.0					23.9	100.0	(1)	100.0	43.1	100.0	7.4	100.0	25.4	100.0

[1] Less than 1/10 of 1 percent. Percentages may not add to total because of rounding.

D-3. When the Foundation supplies educational institutions with large-scale equipment, does a decrease in the amount of time available for teaching by senior professors and graduate students result?

D-4. What effect has the transfer of ownership of facilities and equipment to the grantee from the Foundation had upon the subsequent geographical distribution of research grants?

D-5. Do you anticipate that the Office of Education, pursuant to authority of the Higher Education Facilities Act, will take over a large measure of support of science facilities that heretofore has been mainly an NSF responsibility?

Facilities and equipment acquired through Foundation grants fall into two categories. These are: (*a*) the research apparatus acquired as part of a research or equipment grant—ordinarily limited to items in the "few thousand dollars" range, though occasionally as high as $10,000 or $20,000; and (*b*) major items of equipment, running as high as several million dollars, and building construction or renovation. "Facilities" grants or contracts are used for both of these purposes.

No detailed study of the amount of teaching done by senior staff and graduate students before and after the receipt of large-scale equipment grants has been made. Continuous contact with research and teaching patterns indicates that there is not a significant reduction in teaching by senior staff and that graduate students, although they may be spending full time on research by the time they begin to work on such equipment, have quite commonly (earlier in their graduate student days) served as graduate student assistants for one or more years.

Large-scale equipment is provided at both on- and off-campus sites. When large-scale items of equipment, such as cyclotrons, reactors, and computers are available on campus, senior staff and graduate students are able to work "at home" rather than losing time in travel to other laboratories where such equipment is available. Research time on major equipment at home can be arranged to allow investigators to meet class schedules.

Certain large-scale equipment and facilities must be off campus for environmental reasons. Radio telescopes must be in areas free of local electromagnetic interference, optical telescopes must be in areas which afford good viewing conditions, field stations must be in or near the natural environment to be studied, and upper atmosphere and space studies must be conducted in cooperation with satellite and probe launch sites, observation or communication sites, and laboratories. Therefore, certain highly important major areas of research cannot be pursued without taking scientists off campus for varying periods of time.

Such major on- and off-campus research facilities do not, in themselves, reduce the time available for teaching. They enable scientific instruction—particularly at the graduate level—to keep abreast with current advances in the various disciplines and graduate students to participate in research as part of the educational experience. Any reduction in time spent in formal instruction is offset by student experience and the quality of the formal lectures given. Upper division undergraduate and graduate students, in particular, receive significantly more valuable training through the availability of the most advanced equipment and the direct association with senior scientists working in forefront areas. At the graduate level, research and grad-

uate training should be intertwined. The availability of large-scale equipment lends itself to this process.

Apparatus of many kinds (but generally not such as might be called large-scale equipment) is often provided as part of an individual project research grant awarded on the basis of the research competence of existing faculty. Such equipment usually will not affect the institution's future ability to acquire significant increased research support. If an investigator, using such equipment under NSF research grant sponsorship, changes his organizational affiliation but continues his research activities in the same scientific area with NSF support, it is not uncommon for such equipment to be transferred to the new institution for support of that investigator; thus, even though title to the equipment is vested in the institution, the equipment is in support of the individual's research.

Where significant amounts of research space and large items of research equipment, such as computers or reactors, are acquired, the recipient institution may thereby improve to some degree its competitive position as it seeks further research support. The purpose in granting funds for buildings and major research equipment is to enable the institution to increase or upgrade its research and research training activities. These awards are made on the basis of existing or potential scientific merit and it is expected that the resulting expansion of research programs or increases in faculty will make it easier for the institution to obtain the required supporting funds. Therefore, those geographic areas most competitive for research facilities and equipment by virtue of their need and potential for upgrading will compete most favorably for a corresponding share of Federal research dollars.

Judging from recent enactments of authority and appropriations, the Office of Education probably will hereafter provide an increasing fraction of the support of classroom and laboratory buildings, and the National Science Foundation probably will, in turn, tailor its science facilities support to those areas where the Office of Education cannot provide adequate coverage, where special or urgent needs manifest themselves, or where novel or highly specialized facilities—e.g., research laboratories and major specific items of research equipment—must be developed. The Foundation's area of emphasis in these programs will continue to be at the graduate level. The facilities programs of the Office of Education and NSF, therefore, are complementary. The primary responsibility for meeting the large need for general facilities falls on the Office of Education, and the important responsibility for meeting urgent and specialized requirements (such as accelerators, biotrons, or reactors) and for innovation falls on NSF.

Section 2 of the Higher Education Facilities Act of 1963 states that a primary purpose of the legislation is to make certain that "the Nation's colleges and universities are encouraged and assisted in their efforts to accommodate rapidly growing numbers of youth * * *." Two titles of this act provide for grants for academic facilities. Under Title I, public and private nonprofit institutions of higher education in each State submit projects for the construction of undergraduate academic facilities to a designated State commission. Priorities are assigned to eligible projects and appropriate recommendations are made to the Commissioner of Education. Under title II,

institutions of higher education submit proposals for graduate academic facilities support directly to the Office of Education. An Advisory Committee on Graduate Education advises the Commissioner in the selection of grantees. The purpose of title II is "to increase the supply of highly qualified personnel critically needed by the community, industry, government, research, and teaching * * *."[1]

While the funds available for the support of graduate facilities through the Office of Education (under title II) exceed those funds available through the National Science Foundation, it is important to note that the authority of the Office of Education covers the support of construction of classroom and laboratory buildings (and ancillary equipment) in many fields of learning—plus libraries. Thus, in trying to provide adequate facilities to meet the needs of an expanding student enrollment, the Office of Education will face increasing demands for many kinds of graduate-level facilities—primarily the construction of buildings—across the entire spectrum of educational activity.

Thus far, out of 85 awards under title II, 51 (60 percent) were grants for nonscience graduate facilities.[2] The Office of Education has become a vitally important source of funds which can assist in meeting these important needs. As we understand their mandate and their plans, it appears highly unlikely that OE will wish to or be able to provide funds for major scientific research facilities, such as oceanographic research ships, particle accelerators, biotrons, or the like, for some time to come, if ever.

The Foundation, on the other hand, is concerned primarily with scientific excellence and scientific growth. For this reason we have stressed the importance of providing adequate, modern laboratory space where such facilities are required, either to maintain excellence in research and education or to encourage growth. As the Nation continues to invest in basic science, it is important to make certain that a lack of adequate science facilities does not impede our progress in science. Furthermore, there are certain types of research facilities for which support cannot be obtained through the title II program of OE, such as space for postdoctoral research fellows and for individual faculty members who may not be involved in graduate training. The Foundation provides support for these special needs. Thus, the Foundation, because of its responsibilities toward the progress of science, is often uniquely positioned to advance that progress by responding perceptively to requests for facilities.

Because there are basic differences between the objectives of the facilities programs of the Office of Education and the Foundation, these programs should be viewed as largely complementary to each other.

In 1962 a study conducted by the Foundation indicated that, for the decade 1963–72, the requirements for science facilities at colleges and universities would amount to $7.5 billion. On the basis of our present knowledge we believe that the needs for academic facilities in the years ahead will become even more evident than at present, and that these needs will best be met by the concerted efforts of several Federal agencies.

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[1] The Higher Education Facilities Act of 1963, Public Law 88–204, sec. 201.

[2] Estimate based on "Notification to Members of Congress Regarding Public Law 88–204, the Higher Education Facilities Act of 1963"; HEFA Reports Nos. 60 and 110.

D–6. With respect to the national research centers, you testified as follows:

> *They must continue to be supported and their programs should be strengthened and expanded. Perhaps from time to time there may be occasion to establish more of them in special fields.*

Is the Federal Government funding the entire cost of the national research centers? Do participating universities contribute any part? Can you provide information on funding of research centers in general, and also on relative costs of supporting research at centers vis-a-vis project research?

The Federal Government is funding, for all practical purposes, the entire cost of the national research centers. Each of the centers is managed by a private nonprofit corporation established by an appropriate group or universities. The corporations each have some private funds at their disposal, including a small pool established through initial contributions of a few thousand dollars each by the participating institutions. In a few instances, the corporations have used their own funds for special needs of the centers which could not be met by Federal funds.

The funds for each center are identified in the Foundation's budget request as a special item separate from the general support of university research and research facilities. The management procedures used by the Foundation are much the same as those used by the Atomic Energy Commission for its national laboratories. The centers are Government-owned, contractor-operated laboratories, in which the management corporation is given broad responsibility and wide latitude to take the initiative in achieving the scientific objective laid down in the contract.

All of the centers established by NSF emphasize cooperation with university scientists. In the case of the observatories, a major objective is to provide observing facilities for outside users. Since these facilities are available at no cost, the effect is to reduce the cost of individual project research by university users. Hence, it is difficult to compare costs of research by the observatory staff with cost by university users without a rather elaborate cost analysis. In the case of the National Center for Atmospheric Research, participation by university scientists in laboratory and field programs is a major goal, in addition to the provision of specialized facilities. The real cost of research at a national center is probably about the same as the real cost at a university. However, contributions by the university, both explicitly identifiable and hidden, probably reduce the cost of research to the Government at a university below that of research at a fully supported center. It must be remembered, however, that our centers have been established to provide research opportunities which cannot be made available at universities, including large and expensive research facilities, and hence it is not strictly possible to make meaningful cost comparisons.

(See also D–7.)

D–7. What are the plans of the Foundation for national research centers to extend the concept to technical areas not presently included? What growth in the Foundation's budget do you foresee for continuing commitments for operations? To what extent is the Foundation involved in the operation and management of these centers?

The Foundation has no specific plans at this time to establish any new centers in technical areas not presently included. In general, it is

our policy to establish such centers only when it has been clearly demonstrated that setting up a new entity is the best (or only) mechanism we can discover for accomplishing the objectives sought. When a new center is proposed, for example, our first question is whether the same objective cannot be gained by strengthening programs in existing institutions.

It is estimated that the annual budgets of the present centers will reach approximately $45 million in the next 10 years, which is $23 million more than the total fiscal year 1966 allocation.

The figure given does not include a telescope for the Kitt Peak National Observatory larger than the presently authorized 150-inch reflector, although such an "x inch" telescope is now under discussion. The estimate does, however, assume construction of an equivalent 150-inch instrument at the Cerro Tololo International Observatory. At the National Radio Astronomy Observatory, a very large array is included, but no provision has been made for construction of a very large steerable paraboloid. The National Center for Atmospheric Research estimate does not include possible applied research and development programs, which might be supported by other agencies. It can be said in general that the need for new major facilities cannot be foreseen and will depend on how these scientific fields advance.

The Foundation contracts for management of the centers with three nonprofit corporations, which are given wide latitude in achieving the broad objectives laid down. Foundation involvement in management includes normal contract administration guided by Federal procurement regulations and continuous technical review by Foundation professional staff to insure that the scientific objectives agreed upon are being pursued vigorously and with emphasis on excellence. The Foundation is not directly involved in operation of the centers.

(See also D–6.)

D–8. Could you provide statistics on annual Federal obligations for research facilities in universities, apart from obligations for research and development facilities combined? What are the projected needs?

The Foundation does not have data from Federal agencies on their annual obligations to universities for facilities that are used exclusively for research. So far as is known, such data are not available from a single source, but would have to be collected from the Federal agencies.

However, the following data are available from agencies on their obligations for combined research and development facilities located on sites of educational institutions. These data exclude obligations for R. & D. plant to Federal contract research centers located on sites of education institutions, and thus represent only Federal obligations for facilities at educational institutions proper.

[In millions]

	Fiscal year 1964	Fiscal year 1965 (estimated)	Fiscal year 1966 (estimated)
Department of Health, Education, and Welfare	$38	$66	$68
National Science Foundation	40	53	58
Other agencies	20	26	21
Federal total	98	145	147

Source: "Federal Funds for Research, Development, and Other Scientific Activities," vol. XIV (not yet published).

It would appear, however, that almost all of these R. & D. plant obligations are for support of academic facilities used for research rather than for development. This assumption is based on the fact that during 1964–66, approximately 95 percent of obligations for research and development, excluding R. & D. plant, to universities proper was for research.

Similarly data are not available from Federal agencies on their projected obligations to universities for research facilities. However, a study made by the Foundation in 1961,[1] based on the relevant information then available, indicated that during 1961–70 a national investment from all sources, of about $2.8 billion would be required in laboratory buildings for basic research in colleges and universities. This estimate included the costs of new construction and fixed equipment.

A broader and more detailed study of college and university physical facility needs was made by the Foundation in 1962. This study indicated that the facility needs of universities and colleges for basic and applied research including graduate training in the sciences for the decade 1963–72 would amount to $7.5 billion:

	Billions
Building construction and fixed equipment (excluding land)	$4.3
Movable apparatus and furnishings to make building operable	2.5
Special and separate apparatus	0.7
Total	7.5

The educational institutions reported that 70 percent of their support was expected to come from presently identifiable sources. Those institutions that felt they could identify these sources of support with some degree of assurance estimated that on an aggregate basis almost 53 percent of the support would come from Federal funds, 34 percent from State appropriations, and the remainder from private sources. Public institutions that identified the probable sources of their support in detail stated that for every dollar of State support, $1 of Federal funds would be required. Private institutions, in contrast, stated that for every dollar of private support, $2 of Federal support would be required.

D–9. To what extent, if at all, does NSF review the engineering feasibility of construction plans for major facilities which it supports at national centers and at universities?

NSF reviews the feasibility of such facilities in terms of the scientific desirability of the concept, their general feasibility, and the general cost. For detailed engineering studies of the construction plans we rely on personnel at the centers or the universities, and their consultants and contractors, although we follow the development of such studies as they progress. For example: All of the architectural, engineering, and construction subcontracts related to the facilities being developed by and for the National Center for Atmospheric Research must be submitted to NSF before execution under the terms of the contract with UCAR.

[1] "Investing in Scientific Progress," 1961–70. NSF 61–27.

The facilities programs of NSF provide funds for specialized and graduate science facilities at colleges and universities. Program specifications, preliminary drawings, and, ultimately, actual working drawings are reviewed to insure that the university is constructing facilities as represented to the Foundation. An architectural unit within the Foundation has been established both to advise the universities and to insure that the Foundation's funds for facilities are well invested.

E. Science Education and Institutional Programs

E–1. In your view, which is more important to the National Science Foundation—the promotion of basic research or the advance of science education?

This question involves two separate but intimately connected considerations: first, which of the two, promotion of basic research or advance of science education, is more important to the Nation; and, second, what the role of the National Science Foundation is conceived to be in the overall effort to meet the Nation's needs.

From the point of view of national needs, it is difficult to see how the two can be separated. The promotion of basic research is fundamental, for it develops new knowledge and advances our understanding of the universe, as well as being the basis for new technological developments which will determine the nature of our economic and military position in the future, and will, perhaps as much as any other factor, determine our continued existence as a Nation. But none of the findings of basic research can be of any use at all without the existence of a corps of citizens capable of making use of that knowledge—capable of translating the fruits of basic research into useful tools, and the new knowledge into guiding principles.

Further, basic research is not an "interim" activity; it must be a continuing one, and for those now engaged in it there must be a continuing flow of replacements—replacements that can be trained only by a long process that ultimately involves, as part of the training, active participation in basic research.

Basic research therefore, in addition to being essential to the maintenance of the continued growth, if not the life, of the Nation, is an essential part of education. But basic research is not *all* of education. There is much of education that must precede that involvement in research that is a part of education—much of education that, especially in its early stages, must establish a broad base upon which can be built any of a variety of possible (foreseen and unforeseen) research specialties. The breadth of an individual's education will in general become narrower and narrower as his inclinations and talents dictate, but his education cannot be structured from the beginning toward a single specialized goal, if only because it is impossible to predict *now* where the frontiers of science will lie 15, or 10, or even 5 years from now. Wherever those frontiers are, the ability to pursue them is not developed overnight; it comes, except for the rare genius, only through a long period of education.

It is thus impossible to say that, to the Nation, one is more important than the other. Over the long haul, they are not separable. This does not say, however, that at one particular point in time we may not have to emphasize, temporarily, one over the other. One can imagine a situation in which it is obvious that basic research is going well, but it

is also obvious that basic research is going well, but it is also obvious that the education pipeline is very thinly populated, and something needs to be done to refill it. Or the education pipeline may be adequately filled, but support of basic research may have dropped to too low a level to provide the necessary opportunities for new research workers and the essential growth of new understanding. Either situation would demand a change in the pattern of support, and one of our pressing needs is for careful assessment of present and future requirements, and for flexibility in our support programs to correct imminent deviations from our determined course *before* they become critical.

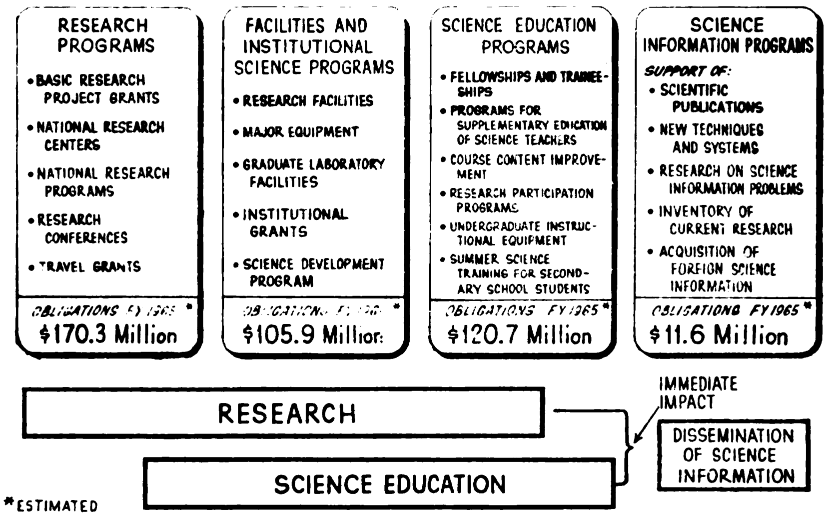
Which of the two is "more important" to the National Science Foundation, then, depends upon two factors: (1) which of them—basic research or science education—is *at a particular time*, most in need of temporary emphasis, and (2) what role the Foundation is expected to play in responding to newly apparent or changed needs. If the Foundation is expected to be a primary force in keeping both basic research and science education vital and productive, it needs not only current knowledge of, but a mechanism that will enable it (insofar as possible) to anticipate or predict the activities of other Federal agencies, and of the civilian economy as well. The very nature of research makes it impossible to arrive at dependable "long-range" predictions; the effort must be continuous, sustained, and uninterrupted. It needs, beyond this, the capacity to act quickly and decisively to meet new or anticipated problems.

Thus, in view of the inherently long-range nature of the National Science Foundation's fundamental task of promoting "the progress of science" on a broad base, it is literally impossible to make a clear-cut distinction between NSF support in research and in education. To promote basic research most effectively over an extended period of time, we must assure the health also of science education.

E–2. The testimony has shown that NSF support of universities is heavily weighted on the side of research, as distinguished from the education of students and the training of teachers. (a) Is this deliberate policy? (b) Do you see any danger of converting our colleges—that is, their science and research department—into great research laboratories?

In my oral presentation 2 months ago, I discussed with you a chart entitled "Mechanisms of Support" (presented again for convenience on the next page). In that chart, you will note that we show two bars labeled "Research" and "Science Education" underneath the boxes headed "Research Programs," "Facilities and Institutional Science Programs" and "Science Education Programs." These two bars were quite intentionally drawn in such a way as to overlap one another along much of their length—symbolizing the fact that in a large majority of our support it is virtually impossible to clearly differentiate between what is "research proper" and what is "education proper." A postdoctoral fellowship, though shown for fiscal and other purposes under the heading "Science Education" is in fact an award which usually involves research as well as education. Most of our research grants to universities are so heavily intertwined with the graduate education process that the two elements cannot be separated in any meaningful way.

NATIONAL SCIENCE FOUNDATION
MECHANISMS OF SUPPORT



Therefore, it seems to us very difficult to determine whether or not NSF support of colleges and universities is "heavily weighted on the side of research," because this quickly becomes a matter of judgment or opinion. There is no absolute measure or standard which can rationally be applied in trying to determine proper or optimum "weighting." As the chart I have mentioned demonstrates, we have no way of determining what fraction of our research support in the universities should be assigned to the research function and what fraction to the education function.

Because, at the graduate level, research is a necessary component of the educational process, its support, in any form is a contribution to education. Furthermore, a significant fraction of the research funds is applied directly to the support of students and their work. For example, we estimate that about $20 million of the Foundation's obligations for research in fiscal year 1965 provided salaries for research assistants who, for the most part, are graduate students; also, an unknown—but significant—portion of "research" expenditures supported the thesis research of this same group and of other graduate students who received their stipend support from sources such as teaching assistantships, fellowships, etc. Another $10 million (approximately) of our research support that year provided salaries for research associates—primarily postdoctorals; their participation in a research team certainly contributes to their advanced education.

An additional $105.9 million of NSF obligations during fiscal year 1965 provided support for the improvement of institutional science programs and facilities. Virtually all of these grants help strengthen the education capabilities of colleges and universities as well as their research potential. For example, grants under the science development program specifically provide for strengthening faculties, development of improved instructional programs, student participation in

research and other measures which enhance the quality of education in the recipient universities. Colleges and universities receiving institutional grants normally use the funds about equally for research and education. Better graduate laboratory facilities, another area of institutional support, directly increase the educational capabilities of universities. Another field of NSF support is the science information programs, for which fiscal year 1965 obligations amounted to about $11.6 million; activities which facilitate and accelerate the dissemination of the results of scientific studies are equally essential to the improvement of science education and the advancement of research.

All of these efforts are, of course, in addition to our direct "education" programs such as fellowships, traineeships, undergraduate scientific equipment program, institutes, course content improvement, etc.

In summary, therefore, one can say that the amount which NSF support contributes to the strengthening of education is roughly comparable to the amount it contributes to the conduct of research. The encouragement of graduate apprentice scientists under research support and the provision of institutional support to strengthen the science education capability are indeed "deliberate" efforts of the Foundation, but the "weighting" of one activity as against the other appears to be less important than to insure the adequacy of both.

It must be noted that to a major degree there is a basic difference between the sources of support for research and support for education. If external sources of support were not available, in many cases research at universities could not be done at all, and in other cases it could be pursued only at a much slower pace or in ways that would be less likely to yield significant results.

On the other hand the basic sources of funds for the educational activities of colleges and universities are non-Federal: tuition and fees, State and local governments, gifts, endowments, and investment income. These sources at least permit colleges to carry out what may be termed their "normal" teaching programs. The severe demands upon these funds, however, mean that it is very difficult and often impossible for colleges and universities to develop and introduce innovations designed to raise the *quality* of education available to students, to expand opportunities to enhance the capability of faculties, to contribute as only institutions of higher education can to innovation in precollege education. Hence, NSF support for education has been geared to raising the quality of education, to enabling institutions and the educational community as a whole to undertake tasks they could not otherwise attempt. The availability of support for education innovation has, indeed, helped to redress the imbalance of 10 to 15 years ago, when Federal funds were available mainly for research and graduate education. Witness to this is the involvement during fiscal year 1965 of thousands of scientists from colleges, universities, and research laboratories in creating new courses and instructional materials, conducting special programs for students and teachers from elementary school to graduate levels, and other educational programs. The search for ways to increase the commitment of leading scientists to education is a continuing concern of the Foundation.

The key problem, I believe, may be less the apportionment of funds between research and education than the total Federal aid available for both purposes.

Finally, it must be emphasized that there is a continuous interplay between research and education in other ways than in the training of advanced students. In addition to their obvious involvement at the graduate level, scientists from leading research departments have provided substantive leadership for major curricular innovation. This interplay is also reflected in many other projects supported by the Foundation, ranging from the "discovery" approach in elementary school science through research participation by high school and college students and teachers to the influence of ongoing research on classroom teaching and the effects of teaching on the identification of fruitful research possibilities.

At this time I see no danger of converting our college and university science departments into research laboratories. I do not believe Federal research support has damaged the educational capability of universities. Rather it has enhanced it, at all levels, especially at the graduate level.

E-3. Do you consider that the act of performing research is in itself a fundamental learning process, of practical educational value to students in college?

Definitely, yes. We are assuming here that the phrase "students in college" refers to undergraduates, since there is widespread agreement that graduate education is intimately and necessarily associated with research—and especially since the position of NSF with respect to the close coupling of research and graduate education is well known.

NSF initiated programs a number of years ago which emphasize the conviction that research participation is of practical educational value to undergraduates. Able college students who engage in independent inquiry as junior colleagues of experienced scientists develop more rapidly in scientific maturity and in scientific competence. They are thus better equipped for—and are more likely to undertake—graduate study than their peers who have not had such opportunities. The effects on college faculty members supervising these students and on undergraduate courses and curricular patterns in affected departments may be more difficult to isolate and identify, but there is no question that these effects do exist and are important as agents of evolution in producing increased effectiveness in undergraduate education in the sciences.

Those working actively on undergraduate curricular improvement, with or without NSF support, agree that one of the ultimate tests of the effectiveness of any academic regimen is the degree to which the student develops an ability to work confidently, effectively, and independently in new situations. There are ever-increasing numbers of efforts being made to engage students in investigative activities during both the college and precollege years so that skill in inquiry will develop along with increasing grasp of fact and concept.

In the period from 1959 through 1965 NSF has made 3,373 grants to colleges and universities to help them provide meaningful research participation (and comparable "special") opportunities for undergraduates. We are confident that the $30.5 million used for this activity has been an important and worthwhile national investment.

(See also E-12.)

E-5. What percentage of NSF's own funding goes to universities or individuals associated with them? Why does not NSF give greater support to nonprofit research groups? To private foundations?

It is estimated [1] that, in fiscal year 1965, 78 percent of the Foundation's total obligations of $409 million [2] for the direct support of science went to universities, colleges, and individuals associated with them.

A principal reason for concentrating basic research support in educational institutions is that these are traditionally the loci of a large proportion of the basic research of the Nation. Furthermore, basic research thrives best and provides important ancillary benefits when it is conducted in conjunction with educational activity, since each complements the other. No other type of potential grantee can offer so much in the way of possible long-range benefit to the country. Therefore, NSF has felt that it had, and has, a particularly important role to play in supporting academic research and educational programs based on the interest and competence of scientists and engineers in our colleges and universities. Increase of support to nonuniversity, nonprofit research groups could have a further deleterious effect of drawing additional scientists away from the institutions of higher education to such noneducational groups.

Nonetheless, NSF has considered with care (and has frequently supported) proposals submitted by nonprofit research groups and foundations engaged in research. Proposals from such groups are considered fully eligible for support and are evaluated in competition with all other proposals. If more such organizations submitted larger numbers of meritorious proposals to the Foundation, there would be more support of such research groups.

E–10. Have Government-wide standards been established for scientific fellowship awards and stipends? If so, who establishes them and what are the standards?

At the time the National Science Foundation inaugurated its first fellowship program, in 1952, it took the lead in convening an informal meeting with other Federal fellowship administrators to discuss provisions of the various fellowships then in existence. Additional meetings, usually chaired by the head of the Foundation's fellowships section, have continued to be held, at first once a year but more recently twice a year. By means of these conferences, a high degree of uniformity has been achieved in scientific fellowships supported by the Government in such areas as predoctoral stipends and cost-of-education allowances.

No Government-wide standards have been established, however. The minor variations that exist sometimes stem from differences in congressional authorizations. In the NDEA-title IV fellowships, for instance, the stipend has been set by Congress for an academic year of study at a figure slightly in excess of the predoctoral stipend in other Federal fellowship programs. Methods of selecting recipients also vary. To illustrate, section 10 of the NSF Act of 1950, as amended, specifies that the Foundation shall select individuals for fellowships solely on the basis of ability. The Foundation has interpreted this language to mean that individuals shall compete for the fellowships in a national competition. Our procedure for selection is that all applicants

[1] This estimate appears in the "Basic Charts and Tables" prepared in connection with the NSF hearings before the House Subcommittee on Science, Research, and Development.

[2] This figure excludes funds for studies of national resources for science and technology, and for program development and management.

are evaluated by panels of scientists assembled in Washington for that purpose, following which the Foundation selects individuals to receive fellowships on the basis of the panelists' recommendations. Other Federal agencies do not have such a legal requirement. For example, in the NDEA-title IV fellowship program, universities that have been allotted fellowships by the Office of Education select the students to be supported. The same is true of the Foundations' traineeship program.

(See also C-1; E-11.)

E-11. How does the Foundation coordinate its educational support with the National Institutes of Health, NASA, the Atomic Energy Commission, the Office of Education, and other Federal agencies that are concerned?

The bases of the Foundation's position regarding interagency coordination are: (1) Mission-oriented agencies must be enabled to engage in such education-support programs as are necessary to permit them to successfully perform their statutory functions; (2) in general, some overlap of effort is desirable because it tends to preclude an undue degree of standardization and control; and (3) coordination must be effected at all levels—from top level, policy-determining groups to program administrators. The most effective coordination seems to be that resulting from informal, day-to-day communication between operating staffs of the respective agencies. The effectiveness of this kind of coordination is dependent upon the desire of the staffs of the sister agencies to cooperate.

Coordinated planning and program management continues to be very effective with respect to the Office of Education, the Atomic Energy Commission and the National Institutes of Health. Because of the relatively smaller commonality of interests, there is less interchange on educational matters (but by no means zero) with DOD, NASA, and other agencies. With respect to the Office of Education, the agency with which coordination is of first importance, coordination is effected in a number of ways. Both agencies have executive-level membership on the Federal Interagency Committee on Education. The Commissioner of Education serves in person on the Foundation's Divisional Committees for Education, the advisory body which guides the development and administration of all of the Foundation's educational activity. Reciprocally, the Foundation's Associate Director (Education) serves on the OE Advisory Committee for the Higher Educational Facilities (title II) activity, an area of major interagency interest. The Foundation's Director of the Division of Precollege Education in Science serves on the OE Advisory Committee to the NDEA title VII program (new educational media) and in that capacity assists in the formulation of OE policy and selection of projects for support in an area of mutual interest. A key program officer of the Foundation's course content improvement activity serves on the OE Advisory Panel on the curriculum and instruction program, the OE program that includes the counterpart of the Foundation's course content improvement activity. Lastly, proposals received by one agency but which might be of interest to the other are exchanged. This sometimes leads to joint support, sometimes to mutually agreed unilateral support, and sometimes to agreement to provide no support.

Each year the Foundation formally utilizes the services of approximately a dozen of the OE staff as consultants to the Foundation to evaluate specific projects. Frequently, the Foundation provides this same kind of consultant services on an informal basis to OE. Lastly, OE has sought advice and suggestions extensively from the Foundation's staff on effective ways of administering various aspects of the new and large program authorized by the recently enacted Elementary and Secondary Education Act of 1965.

The overall result of this varied group of coordinating mechanisms is a set of programs which reinforce rather than compete with each other. Furthermore, we have been able to reach decisions, permitted by the respective statutes, that one agency will refrain from engaging in certain activities that are currently handled effectively by the other.

Community of interest with other agencies in science education is substantially less, and there are therefore fewer coordinating mechanisms. The institutes for teachers in radiation physics and in biology, which are of joint interest to NSF and AEC, are administered jointly by the two agencies. Those projects mutually agreed as supportable are jointly supported: NSF provides for participant costs and the AEC funds the operating costs. Fellowship activities are coordinated through a Government-wide (informal) interagency fellowship coordination group which meets approximately twice each year. In summary, interagency coordination on educational support activities is a matter of continuing concern, and one which has thus far proven manageable and effective.

(See also E–10.)

E–12. At what grade level, in our modern educational structure, does a student chart his course toward science, engineering, social studies, or the arts? Should NSF exert influence by the investment of support at this level? Should your fellowship or institutional support of pregraduate education be proportionately increased or decreased?

In our educational structure the student usually commits himself to a subject matter major during his sophomore year in college. While designation of such a major in science is essential to a career in science and is more often than not followed by such a career, the factors leading to this designation have their origins many years earlier.

According to developmental studies, interest in science and mathematics seems to arise early, even in elementary school. Certainly by the junior high school years, or ages 12 to 14, a significant proportion of boys and girls who ultimately follow careers in science have declared interest in these fields. While there is some additional gaining of "recruits" to science and mathematics through the high school years, in the main there is a decrease in the total numbers because of a falling off from the peak numbers of the junior high school years during grades 10 through 12. Students make decisions which tend to remove them permanently from potential scientific careers by failing to take a full 4- or 5-year program in mathematics in high school, or neglecting to take one of the physical sciences, usually physics. Thus the group remaining in the pool of potential scientists by the time they reach college can be identified by their choice of high school courses. (Of course, large numbers of those with a complete high school program in science and mathematics will not choose to major in these areas

either, but it is very difficult for a student who does not have these prerequisites on reaching college to make up for the lost time if he wants to major in science.)

Thus, it would seem that the important period for the charting of a student's career in a scientific profession lies in the senior high school years. At these grade levels, exposure to new course content materials and participation in activities which extend beyond the usual classroom hours can be highly effective in revealing the attractions of the sciences and can help to cultivate work habits and thought processes necessary for subsequent achievement in these fields.

A particularly effective way of conveying to able secondary school students the essence of what a scientific career is like is to expose them to mature scientists who have an interest in dealing with this caliber of student. NSF has found that an excellent device is the summer program devoted to course work and research participation in laboratories, taught by experienced scientists in an atmosphere of high level performance. Other methods of bringing the student into closer contact with the scientist include arranging for visits of scientists to schools on special occasions, and participation of especially able students in special seminars or meetings held during the academic year.

No one questions the prediction that effective work in science and technology in the decades ahead will require more individuals trained at the graduate level; thus, consideration must continuously be given to the pool from which graduate students will be drawn. There must be a sufficiently large group entering college and predisposed toward science to allow for attrition during the undergraduate years and to permit a reasonable selection ratio for graduate education. In terms of a pyramid, encouragement by NSF of the potential scientist while he is still in high school will enlarge the base in support of the narrow apex represented by the research scientist.

While it is not assumed that it is possible or advisable to divert very large proportions of superior students into the scientific fields, an increase in support of precollege programs would add significantly to the proportions of students studying science in college. For the moment, we do not see any need to alter substantially the relative support of programs of this nature, but they should be provided support at an increased level as other activities grow.

(See also E–3.)

E–13. To what degree do graduate engineers and scientists drift away from their professional vocations into other fields—such as management, trade or commerce, finance or other business? Is this good or bad? (E.g., less than half of chemistry majors remain in the field.) What can be done to improve career counseling?

Whether a student who obtains a bachelor's degree in science or engineering enters employment in his "major" field depends on a complex of factors which vary according to discipline. During certain periods engineers with bachelor's degrees have been widely sought after and an overwhelming percentage are employed in that field within a short time after graduation. Chemists, on the other hand, do not necessarily find that their bachelor's degree qualifies them for rewarding work in the field, or even for routine jobs, depending on the market. A study [1]

[1] "Two Years After the College Degree," National Science Foundation (1963).

of 1958 bachelor's degree recipients (male) 2 years after obtaining their degrees showed the following: Engineers—about 85 percent in engineering jobs; chemists—about 35 percent so employed; mathematicians—less than 20 percent in professional mathematical work (excluding secondary school teaching). These figures reflect, in part, the varying need for advanced degrees before the young college graduate can be considered a full-fledged member of his profession. The figures on secondary school teaching are also of some interest: Only about 10 percent of the engineers and chemists, but nearly 37 percent of the mathematics majors had become secondary school teachers within 2 years after graduation. Listed as college teachers are 2 percent of the engineers, 10 percent of the chemists, and 7 percent of the mathematicians.

Not unexpectedly, enrollments for graduate degrees during the 2-year period between graduation in 1958 and the spring of 1960 show something of an inverse relationship to employment in the field for these bachelor's degree holders—about 22 percent of the engineers, 51 percent of the chemists, and 38 percent of the mathematicians were engaged in graduate study. There is a strong tendency for the field of graduate study to be the same as the undergraduate major, although there is some drifting into related scientific fields.

The designation of an undergraduate major is often somewhat arbitrary, involving a minimum of credits and often supported by a strong minor in a related area of study. Depending on the employment market, the new bachelor's degree recipient may find himself unsuited for work in his major field because of a mediocre academic record, or because of the need for graduate education, or for other reasons. Such factors as these result in some science "dropouts," and some shifting of areas of specialization within the scientific disciplines, whether with respect to the kind of job accepted or field of graduate study undertaken. By and large, I think that these "corrections" within our educational structure are of significant benefit to—and indeed represent an important "freedom" of—our society, and that they permit a fuller development of each individual's interests and his capacity to contribute to the Nation's overall potential.

With increasing years after graduation the tendency to leave the specific field of college major increases. Often this is due to increased scope of job opportunities which leave the specifically technical responsibilities behind. Often a promotion from a technical job to a managerial post keeps the engineer or scientist within the same organization, and his technical or scientific background is still a requirement—though less obviously so—for the administrative decisions he must make. A factor of importance in shifting of careers from the technical to the more general or administrative is the obsolescence of knowledge and skills. This is an especially serious matter in engineering where the rapid advance of technology nowadays overtakes the engineer 5 or 10 years out of school. Refresher training has become a critical issue in this field, just as continued scholarship and advanced training have always been considered vital for creative scientists.

Receipt of the doctorate, in general, results in a strong commitment to the field in which the degree is earned. Of those who had obtained the degree by 1960, 92 percent of the engineers, 90 percent of the

chemists, and 84 percent of the biologists were working in the fields represented by their degrees.[2]

Career counseling can be just as useful in helping keep out of the pipeline those students who have low aptitude for or low interest in science as it can in encouraging the able and interested student to undertake a scientific career. The key issue is the basic competence of the counselor more than better techniques of counseling. Further strengthening of training programs for counselors, particularly with regard to increasing their understanding of matters related to the scientific and technical professions, would be very helpful for high school and college counseling staffs. Also important, however, is an early introduction of the student to realistic situations in the discipline of his choice—provision for experiences such as extended contact with working scientists, participation in research, and involvement in directed "advanced" study—both before attending college and during his undergraduate years, so that he can make a more adequate judgment as to his ability to fit into such careers.

(See also H–7.)

E–14. In supporting science education over the humanities or one field of science more than another, does the Federal Government incur an implied obligation to provide employment in the future for those graduates it has supported? Do students incur any implied obligation to stay in the field or to work on federally funded programs?

Recipients of NSF fellowships and traineeships are explicitly advised that acceptance of these awards does not obligate them, the Foundation, or the U.S. Government in any way with regard to future employment or future services of any kind. Nor is there any implied obligation of future employment in other Foundation-supported activities. However, in certain programs specifically designed to enhance the competence of individuals to do the job to which they are already committed—e.g., teaching of science—preference is shown (properly, we feel) to those who indicate their intention to resume their regular kinds of employment at the completion of their NSF-supported training activity.

Some other Federal agencies that support educational programs also employ relatively large numbers of scientists and engineers. They believe that their contribution to increasing the supply of trained scientific manpower will assist them in recruiting the highly qualified personnel they will need in the future by adding to the pool of trained manpower in their fields of interest.

It is estimated that more than half of all R. & D. scientists in the United States are working for or on behalf of the Federal Government. We can thus be sure that a significant proportion of those persons receiving training with Federal assistance will eventually be involved in work of direct importance to the Government. Those who enter jobs which are not directly associated with Federal missions nonetheless contribute in a variety of ways to the advancement of knowledge, to the education of our youth, and to the production of goods and services important to the health of our economy.

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[2] This information was obtained from data acquired in the postcensal survey of professional and technical manpower.

E-15. Could you provide results of any studies of the short- and long-range national needs for support of basic science and science education, and how are these needs reflected in any long-range plans of the Federal Government and of the NSF itself?

I take it for granted that a number of published studies dealing with "the short- and long-range national needs for support of basic science and science education" are already available to the committee. What I have in mind here are not only the various studies and surveys conducted by the Foundation on the Nation's current and future resources for science, which are relevant to the problem of determining national needs over the shorter and longer run, but also a body of published materials for which the Foundation has no direct responsibility even though it may have provided staff or other assistance in their preparation. Among these are reports by the President's Science Advisory Committee; by the study panels which operate under the auspices of the Committee on Science and Public Policy of the National Academy of Sciences and by the Committee itself; and by ad hoc study groups or committees created by different agencies. In addition, there are still other examples of published reports in the development of which the committee has played a key role. Its contract with the National Academy of Sciences has resulted in "Basic Research and National Goals." By arrangement with NSF it has made provision for the publication of a series of reports on science education, the first of which, "Science Education in the Schools of the United States," appeared in March of this year.

It is not difficult to show that the results of a handful of studies of "national needs" have been reflected in the longer range planning activities and decisions of the Foundation and of the Federal agencies concerned with basic research and education in the sciences, and even of the Federal Government as a whole. I could cite, by way of illustration, the influences—in some cases extremely far reaching—exerted in this regard by such studies and reports as "Science: the Endless Frontier"; PSAC's "Education for the Age of Science" (1959); "Scientific Progress, the Universities, and the Federal Government" (1960); "Meeting Manpower Needs in Science and Technology" (1962); and "NSF's Government-University Relationships in Federally Sponsored Scientific Research and Development."

A recommendation made in the last, for example, laid the basis for Public Law 85-934 (1958) which permits all science-supporting agencies to employ the grant device as well as contracts. PSAC's 1960 report on "Scientific Progress, the Universities, and the Federal Government" played a role in connection with the development of NSF's institutional grant program and its science development program. The observations made in PSAC's 1959 report on "Education for the Age of Science" have been reflected in the enlargement of NSF's efforts in the areas of course content improvement and curricular reform. In the expansion of Federal programs for the support of graduate students in the sciences and engineering since 1963, a definite role may be attributed to PSAC's report, "Meeting Manpower Needs in Science and Technology," of the preceding year. The PSAC-inspired "Towards Better Utilization of Scientific and Engineering Talent—A Program for Action" (1964) has given us food for thought for some time to come.

I would do less than justice to the importance and difficulty of this question, however, if I stopped at this point in my reply. It is important to recognize that all studies dealing with problems of short- and long-run "national needs," whether prepared for internal use or for general publication receive serious and searching consideration by the various Federal agencies and by the Congress. They are grist for the mill of continuing policy and program review and planning activities deeply embedded in governmental processes which have to take future "national needs" into account. For this reason, however, it is frequently extremely difficult, without undertaking intensive investigation, to identify the influences exerted by any specific study of the kinds to which the committee refers and to show their reflections in the long-range planning of an individual agency or the Government as a whole. Some studies, moreover, may exert their major influences indirectly and over long periods of time. I would be surprised if this did not turn out to be the case with "Basic Research and National Goals."

The nature of the question encourages me to make two other observations. The first is that long-range planning activities with respect to the support of basic research and education in the sciences represent a fairly recent concern in the Foundation and other agencies of the Federal Government. The methods for comprehensive long-range planning in relation to short- and long-range national needs are still at an early stage of development. Undoubtedly, they can be vastly improved, but no one should minimize the inherent difficulties associated with attempts to assess the character of "national needs" for a highly uncertain future.

The second observation is that the main point of the question may, perhaps, be stated as follows: "Will current U.S. and NSF policies in the support of basic research and education in the sciences, if they are permitted to stand unchanged, meet the national needs in the long-range future?" Put in this form, the question virtually compels one to recognize a major lack in the studies concerning long-range national needs. Those which have been undertaken tend to focus on the interests and resources of either separate disciplines or individual agencies, rather than on those of the Nation at large. In all honesty, it must be admitted that thus far there have been no broad, systematic, and intensive studies designed to develop an understanding of alternative policy structures and options open to the Nation as a whole and to assess the associated opportunities and risks, as well as the impact, which such policies and choices might have on individual agencies, disciplines, and the Nation's goals. NSF has recently begun a series of exploratory activities designed to help develop such understanding. The PSAC "summer study" currently in progress is exploring the long-range needs for academic research support.[1]

There is a growing—worldwide—concern with respect to these matters. Scholars in a number of countries have begun to investigate, in a systematic way, economic and other aspects of these problems. I cannot with confidence predict the quick resolution of the many policy issues that are involved in this domain, but I am reasonably sure that within the next year it will be possible to list a number of new and promising developments which no one could have foreseen 5 years ago.

[1] See also our response to question B–7.

E-16. In your testimony you noted that the Foundation's science development program was established to boost near-excellent institutions to first-rate status and in the future to assist promising departmental "islands of strength." (a) What criteria are being employed for awards in either case? (b) What are the total national needs and what are the fiscal implications for the Foundation?

(*a*) The Foundation's science development program was announced in March 1964 with the major objective of increasing the number of institutions of recognized excellence in research and education in the sciences.

The criteria used in making science development grant selections are necessarily rather broad since proposals vary widely. As examples, the following broad criteria are considered in evaluating each proposal:

1. Administration and management:

(*a*) Evidence of interest and support from all sources, e.g., alumni, trustees, State legislature, Federal agencies, and community.

(*b*) Presence of effective administrative leaders (president, vice presidents, etc.).

(*c*) Strength of scientific leadership (deans, department heads, faculty, etc.).

(*d*) Effectiveness of the organization proposed for carrying out the science development plan.

2. The present situation:

(*a*) Existing strength in science to serve as a base for the proposed development.

(*b*) Evidence that significant improvement is underway throughout the institution's science activities.

(*c*) Collateral strength, including strength in the humanities, which will contribute to the success of the plan.

3. The science development plan:

(*a*) Relationship of the proposed plan to the institution's overall development plan (extended forward at least 5 years).

(*b*) Evidence that personnel requirements have been realistically appraised.

(*c*) Likelihood that the level of quality achieved and the level of funding required can be maintained after NSF support from this program has terminated.

(*d*) Commitment of institutional resources for both the immediate and distant future.

(*e*) Possible favorable impact on nearby institutions (through collaborative programs).

(*f*) Possible adverse effect upon other institutions.

The above criteria are used in the present science development program, where the emphasis is on helping the institution as a whole take a major step forward in its scientific strength. We hope soon to initiate a new program of smaller grants in which the institution will present a plan for significant improvement in its work in a selected scientific field where it has some potential for excellence. This program will not expect to bring about a significant change in the institution as a whole. Criteria for the program will focus more on the available faculty and plans for strengthening the particular field. We

will, of course, require evidence that the institution is ready and able to back the proposed move. In all cases, there will have to be an existing "pocket of strength," and in no event will we simply give the administration a "hunting license" to recruit an entirely new group.

(*b*) There are no good estimates concerning the total national needs. The main objective of the present science development program is to increase the number of institutions with top quality science programs. Also, it is recognized that a 3-year grant of $3 to $5 million can serve mainly as a major boost. Even with this limitation, it may be noted that by the end of fiscal year 1965, 68 institutions had submitted science development proposals requesting a total of $275 million. To date, the Foundation has announced grants totaling $35,679,000 to 10 institutions. The budget for the science development program for fiscal year 1965 was $28 million and for fiscal year 1966 is $40 million. A few million dollars of the latter will be devoted to the program for developing departmental "islands of strength." It is estimated that 40 to 50 additional proposals, amounting to $160 to $200 million, will be received in fiscal year 1966. It is clear that the present budget structure permits only a small fraction of institutions to receive a major science development grant.

The experience of the Foundation during the first year suggests that additional and different institutional development programs are needed for different reasons. For example, many less visible institutions have immediate needs and potential for relatively great upgrading in the quality of their science programs. Also, most liberal arts colleges appear not to be well-suited to compete in the present program.

While it is now clear that the Foundation's science development program, as presently constituted, cannot meet the variety of needs present in the undergraduate, small, liberal arts colleges and even in some of the developing universities, staff work is proceeding in an attempt to determine how NSF can best approach a problem of such magnitude.

E–17. What contribution have the small college and the young unknown investigator to make toward the betterment of science? What specific effort does NSF make to assist them and take advantage of their potential?

The contribution of the small college to the betterment of science may be measured in many ways. In a quantitative sense, if one divides the approximately 1,130 institutions offering science instruction at the baccalaureate level into those that produce more than 150 baccalaureates in science per year and those that produce 1 to 150, about 942 colleges appear in the second group. Approximately 33 percent of the annual national supply of new science baccalaureates graduate from these smaller schools, and thus two-thirds of each year's group of graduates emerge from the 200 or so larger institutions.

In terms of quality the small colleges range from superb to very weak; their students also represent a wide range in terms of ability. As a consequence, the graduates of the small colleges have emerged at all levels of eminence in our society.

The Foundation's efforts to improve the quality of undergraduate instruction include components of faculty development, support of curricular improvement through such groups as college commissions and writing groups, implementation of course and curricular modifica-

tions through the equipment program, and support for the participation of able undergraduates in research. The Foundation also supports a variety of special projects such as the formation of inter-institutional associations designed to identify and encourage able young scientists who are trying to carry on both instructional and research activities in the small colleges.

The relative magnitude of NSF efforts in this area is small when compared with the total need. However, the Foundation has devised and tested a variety of approaches to the improvement of quality of science education in the colleges and these approaches are available to serve as models for more massive assaults on major problem areas.

As for the young investigator, the Foundation recognizes that all established scientists were once young and unknown. Means now exist for helping the able student of science to complete his training—but more needs to be done to make sure that he can gain support for his first independent research.

A significant effort by the Foundation in this direction is its program of research initiation grants in engineering. These grants are restricted to younger faculty members who received their doctoral degrees within the past 3 years and who have not received substantial research support since starting their teaching careers. During the past fiscal year 126 grants were awarded to 71 institutions (65 percent of those applying) in 36 States. The Foundation's interest in increasing the potential of young faculty members in the smaller institutions is pointed up by the distribution of the grants. Only 14 percent were awarded to the 12 major schools which collectively award 50 percent of the doctoral degrees in engineering; the vast majority (86 percent) were awarded to the smaller engineering schools. For the past 2 years more than $1.5 million of the Foundation's engineering research funds have been reserved for this program. An even larger amount is planned for fiscal year 1966.

(See also E–20.)

E–18. On the subject of faculty training, you testified as follows:

> ***Research funds should be made available to promising younger members of science and engineering faculties who have not yet achieved reputations and whose chances of securing Federal research support are understandably small, given the accepted and desirable criteria of proven merit and high quality.***

If NSF supports meritorious proposals and makes its judgments on this basis, it is really considering a double standard to support also "meritorious" people. What relative weights should go to the person and what to the project?

In evaluating proposals from an established, older investigator it is felt that substantial weight should be given to his research performance in the recent past, since he usually will have produced a number of papers which have been widely read and judged by many of his colleagues. The research proposal under immediate consideration needs to be given relatively less (though still careful) consideration unless it happens to require the purchase of new and expensive equipment or services.

In the case of a younger person more weight must be placed on the evaluation of his proposed project since information derived from an analysis of his past work is much more limited. Were it not essential to encourage younger men, and for the fact that the most

original ideas are frequently produced by them, limited support funds would almost always be channeled to older, proven investigators.

E–19. Does the Foundation concur with the targets for master's degrees and Ph. D.'s established by the Gilliland Panel? Are these targets being met? If not, what steps are necessary to increase production, particularly of engineers?

The Foundation agrees with the import of the report [1] of the President's Science Advisory Committee (the "Gilliland report"), issued December 12, 1962, to the effect that an adequate supply of well-trained physical scientists, engineers, and mathematicians is essential to the orderly progress of this Nation. The Foundation also believes that the problems inherent in the area of scientific manpower are continuing ones and require periodic examination, reassessment, and actions. The problems involve a complex interplay between the nature and scale of our training of persons to various levels of competence and the way in which scientifically or technically trained persons are utilized. The latter necessarily must include consideration of the needs of both the public sector and the private sector. Our total manpower resource should at all times be adequate to support large-scale, national, scientifically related programs (e.g., defense technology, supersonic transport development, the space program). But we must also keep our economy healthy and growing—and this too demands trained scientists and engineers. Obviously we want to make sure if we can that we have available at a given time the manpower necessary to do the job then to be done. And there is a distinct difference between what has to be done and that which would be desirable to do, although the distinction is hard to make in practice. The most acute shortage has been, and almost by definition will continue to be, at the highest levels of competence. Measuring competency levels of those trained in terms of level of degrees granted is not uncommon and has certain practical advantages. It is not of course wholly valid. Especially when viewed in terms of what engineers do and what they will be called upon to do in the future, and relating these to what engineering students are taught (there are great disparities in curriculums and objectives from school to school) absolute numbers, either as to future supply or demand, should be viewed as valid only within wide limits of error.

These points of view lead, in turn, to viewing the manpower production goals of the Panel (7,500 Ph. D.'s and 30,000 completing at least 1 year of graduate study in EMP fields in 1970) as being not unreasonable—but also not firmly fixed. The Foundation would consider these goals to be a reasonable approximation of the needs as seen at a given point of time. The Panel did not claim that its target figures were the "right" ones—but rather that they represented goals that could be reached and that should be viewed as being worthy of additional Federal investment to achieve. NSF has been and is in agreement with this view. It is important to remember that many important and relevant matters were left essentially untouched in the report under discussion, for it was (as its title notes) the first of a series. Among the problems not dealt with were: graduate training needs in the social sciences and the life sciences; postdoctoral training in general; and the ways in which teaching and research assistant-

[1] "Meeting Manpower Needs in Science and Technology." Report No. 1: "Graduate Training in Engineering, Mathematics, and Physical Science."

ships could best be made use of in moving toward a greater production of advanced degrees.

Graduate degrees awarded in the physical sciences, mathematics, and engineering reflect the increased emphasis placed upon these fields, and have increased through the academic year 1963–64, the last for which data are available. Projections prepared by the Office of Education and by the National Science Foundation agree that the goals proposed for 1970 by the Gilliland Panel are attainable, providing these trends continue.

It must be emphasized, however, that the continuation of the trends and the attainment of these goals depend upon the further commitment of resources of faculty, facilities, and student support. We are in a position where the proposed goals are now possible of attainment thanks to the hitherto unprecedented support provided for these fields in the late 1950's and early 1960's. However, further increases of about 60 percent in the doctoral and master's degrees awarded in 1970 over 1964, which will be necessary to meet the Panel's goals, will require both the continuation of past efforts and a substantial further effort on the part of all parties concerned.

E–20. Since research and science education are so intimately linked throughout the NSF authority and program, what does this portend for the small college which is unable to support a vigorous R. & D. effort but still wishes to graduate high quality bachelors of science?

The linkage between instruction and research activity becomes progressively greater at progressively higher levels of education. At the graduate level, for example, they are virtually synonymous.

At the undergraduate level some research type activity, for both teachers and students, is important. It should be borne in mind, however, that the relevance of research to undergraduate instruction is to be found more in its instructional import than in the significance of its results in terms of new knowledge. It follows then that the criteria for support of *research activity* relevant to undergraduate instruction should be different from those relevant to the discovery of new knowledge. Many small colleges do carry on research activity oriented toward its instructional values and with salutary results. Many more colleges could do so.

The use of research as a means of supplementing undergraduate instruction in science is limited for several reasons. First, some faculty members in smaller colleges seem, perhaps for reasons of prestige, to be more interested in research for its own sake than for its instructional value. Because they are typically in a less favorable position to conduct original research, they are not very successful when they compete for research funds. Second, many other faculty members in smaller undergraduate institutions simply are not convinced of the instructional value of research either for themselves or their students. They are not aggressive in starting those research activities which would be possible even within the limits of their own competence and available facilities. Third, many college teachers are so inexperienced in research that they are unable effectively to utilize research as a supplement to instruction. Fourth, there is relatively little money available to support research activity for its instructional values.

NSF does support, through its science education activities, a substantial amount of "research participation" activity in a large number

of undergraduate institutions. There are programs for both faculty and students. The educational potential is the basis of support. With respect to the support of research per se—that is, for the discovery of new knowledge—the Foundation's research support programs have been oriented toward "quality" research. With limited funds for the support of basic research, the Foundation has to date deliberately chosen (wisely, I believe) to invest its research funds in those projects judged to have highest scientific merit. Within this framework, NSF has provided support to a substantial number of institutions that give only a few (if any) advanced degrees. For example, in fiscal year 1965, we made 92 grants to 59 colleges which grant no more than a bachelor's degree; 214 grants were made to 82 institutions that grant no more than a master's degree. As its appropriations grow, the Foundation hopes to extend its research support to include new research programs in which the instructional values play a larger part in the decisionmaking process.

The whole problem of research support in the colleges is complex and cannot be solved on any formula basis. Research funds injudiciously employed can have the effect of converting small colleges into institutions so research oriented as to have deleterious effects on undergraduate instruction. There is little danger of this happening at present, simply because there is not a great deal of research being supported in small colleges. It is the Foundation's belief that its primary role in this area is that of providing more support for faculty training in research activity and for research activity for its instructional value.

(See also E-17.)

E-21. Scientific talent in Government is concentrated, of course, in the executive branch. Do you believe that the scientific disciplines, including mathematics and engineering, should have more representation in our legislative bodies?

E-22. Has any effort been made by anyone to attract more scientists and engineers into politics? Should an attempt be made to induce technically trained people to run for public office? If so, how would we go about it?

I believe that more scientists and engineers serving in legislative bodies would be in the public interest. With the increased importance of science and technology in our national life, it is obviously desirable that those elected to public office have or develop an adequate understanding of the way in which these fields can and probably will affect the quality and "style" of our society. As legislators have come to deal more and more with scientific and technological problems, they have found it necessary to rely on professional advice and understanding which, to a large extent, comes from outside of legislative bodies. Legislators who, at the same time, are scientists or engineers would incorporate into the legislative process a more direct understanding of these problems. In suggesting that more scientists and engineers might serve—and serve well—as legislators, I do not advocate disproportionate representation of the scientific community. I have, in fact, no representation formula in mind. There is only the general notion that an increase of scientist-legislators would serve more than the scientific community: it would serve the Nation. I should also like to add that more and more legislators are becoming better

prepared for dealing with scientific and technical problems by virtue of the great effort they have put into learning and understanding science in connection with their legislative duties. Over the longer pull this process will be greatly enhanced by the intensified—and higher quality of—education in science now given in our schools, colleges, and universities to those students who are preparing for careers in fields other than the sciences.

I am not aware of any specific efforts which have been made to attract more scientists and engineers into politics. Some scientists and engineers have organized themselves so as to participate in recent national political campaigns. I should be surprised if this indication of interest in the political situation did not lead some of these individuals to seek public office. I believe it would benefit the Nation if some additional number of technically trained people sought and achieved public office, but I have no plan to offer for inducing more such personnel to enter politics.

E–23. Just how does the Foundation select universities and colleges for institutional support? What factors are evaluated besides educational merit? Is any consideration given to such things as geographical location; to the economy of the area—for instance, agricultural versus industrial; to climate, or population density or political status?

Institutional support from the National Science Foundation includes three programs, namely, the science facilities program, the institutional grants program, and the science development program. Also, the undergraduate instructional scientific equipment program is institutionally oriented, though at the departmental level.

Eligibility to participate in the science facilities program is limited to institutions offering graduate science degrees. In addition to making a case for the merit of the work to be done using the facility in question, the institution must demonstrate immediate need to maintain or increase its existing strength or improve its present quality of research and education. Matching on at least a 50–50 basis [1] from non-Federal funds is required. The science facility proposal submitted by an institution is evaluated in minute detail by the Foundation. A site visit team, made up of consultants and National Science Foundation staff, visits the institution. The recommendations made by the staff and the consultants are reviewed at several levels within the Foundation and, finally, the selection of the institution to receive a science facilities grant is made by the Director, his decision in the most expensive cases being subject to approval by the National Science Board. While there is no stated requirement to distribute funds on a regional basis, consideration is given to such items as the number and quality of science students in an area. During the past 6 fiscal years, science facilities grants have been made to institutions located in 49 States, Puerto Rico, and the District of Columbia.

In the institutional grants for science program, any institution receiving NSF grants for research (and/or research participation) is eligible to apply. The amount of the grant is determined by applying a formula to the total amount of such grants during a 12-month period. The formula provides for 100-percent matching of the first several thousand dollars of the base, and tapers sharply thereafter.

[1] In practice, the institutions "overmatch" to a substantial degree.

This tends to favor the smaller institutions and results in a widespread distribution of grant funds. In 1965, 376 colleges and universities in all 50 States, Puerto Rico, and the District of Columbia received institutional grants.

In the science development program, any institution of higher education granting the baccalaureate or higher degree in science or engineering is eligible to apply if it feels its present strength is such that within a 3- to 5-year period it can achieve high quality in some substantial portion of its science programs by receiving a science development grant. (Institutions having already attained positions of recognized excellence in their science programs are requested not to apply for these funds since they can and do compete successfully in other Federal programs as a means of maintaining their status.) When a science development proposal is submitted to the Foundation, it undergoes extensive evaluation by many individuals in the Foundation; it is reviewed by several scientists from outside the Foundation; the institution is site-visited by a team made up of Foundation and non-Foundation personnel; meritorious proposals are presented to a Science Development Advisory Panel, who make recommendations to the Director; a special Science Development Program Committee of the National Science Board advises with the Director in reaching a final decision to make a science development grant. The 10 institutions receiving science development grants to date are located in widely separated geographic areas. While no formal requirements or formulas have been instituted to assure regional distribution, this is clearly recognized as an important element. While there is recognition that a major grant has an impact upon the economy of an area, there have been no guidelines set up for utilizing this factor as more than a general subjective element in the decision process.

The undergraduate instructional scientific equipment program considers proposals from:

Type 1. Colleges and universities in the United States and its territories offering a baccalaureate in one or more of the sciences or in engineering.

Type 2. Other 4-year institutions, as well as junior and community colleges offering freshman and sophomore course in the sciences acceptable for transfer credit to a 4-year college or university granting a baccalaureate in one or more of the sciences.

In selecting proposals for support, the Foundation staff is assisted by panels of scientists drawn from the academic community, research organizations, and professional scientific societies. The recommendations of these panels form a major element in the Foundation's determination of whether a grant will be made. Support by order of merit to the extent of available funding is the rule except that in cases of substantially equal merit, consideration is given to other factors such as disciplinary, institutional, and geographical distribution.

E–24. What steps has the Foundation taken in response to the 1960 report of the President's Scientific Advisory Committee which advocated the development of additional centers of academic excellence? Has there been any effective geographical dispersal of institutional support of our institutions of higher learning?

One response to the President's Science Advisory Committee report, dated November 15, 1960, and titled "Scientific Progress, the Universities, and the Federal Government," [1] was the expansion of the graduate science facilities program for the purpose of increasing "the quality and quantity of research results and the number of trained scientists."

Requiring much longer study by the Foundation was a response to the recommendation for "an increase in the number of universities in which first-rate research and graduate teaching programs are present." In preparing to initiate such a science development program many things were done. The National Science Board discussed the question at length on numerous occasions. A special "science development committee" (comprised of senior members of the Foundation's staff) visited several institutions to discuss institutional needs. Institutional development ideas were discussed with NSF Divisional Committees.

In March 1964, the Foundation announced its science development program for colleges and universities. In my foreword to the announcement, the new effort's relevance to the Seaborg report's findings was acknowledged in these words: "It is generally recognized that there is a need for additional centers of academic excellence in the sciences. The President's Science Advisory Committee in its report of November 15, 1960, emphasized this need." The major objective of the science development program is to increase the number of institutions of recognized excellence in research and education in the sciences. This program's primary purpose is to accelerate improvement in science through the provision of funds to be expended in accordance with carefully developed plans designed to produce significant upgrading in the quality of the institution's science activities. Grants are made to institutions judged to have the greatest possibility of moving upward to a high level of scientific quality and to have sound plans for maintaining this quality.

The Foundation's institutional programs have not been subjected to a specific percentage distribution requirement by region. The tables on institutional grants provided in partial response to question A–21 give data by State for fiscal years 1963, 1964, and 1965 on the distribution of institutional base grants and of grants for science facilities to educational institutions. Institutional base grants are based on a formula applied to the amount of research grants an institution received in a 12-month period, and science facilities grants are made in response to approved selected proposals requesting funds for needed science facilities.

The science development program has been in operation 1 year and only 10 grants have been made. A table of distribution for science development grants is also provided at the end of question A–21.

E–25. Are the NSF institutional grants consistent in policy and content with those of National Institutes of Health, NASA, and other Federal agencies? What is the amount of private sector support in the same programs?

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[1] More commonly designated as "The Seaborg Report."

I. POLICY AND CONTENT

There are several Federal programs of "institutional grants" of one kind or another, as, for example, the formula grants for agricultural research to agricultural experiment stations under the Hatch Act and the formula grants for operational assistance to schools of public health. The Federal programs most nearly comparable in NSF's institutional grants for science, however, are NIH's general research support program and NASA's sustaining university program.

The NSF, NIH, and NASA programs are consistent in their policy of relying upon the responsibility, creativity, and initiative of higher educational institutions to achieve national goals in science. All three programs under discussion provide Federal grants to institutions as such, rather than directly to individual investigators. The programs rest upon the assumption that strong and effective educational institutions are indispensable for the fulfillment of the missions of the agencies. Therefore, some rather broad support of institutional scientific activities is in the national interest and in the interest of the supporting agencies. The programs allow a considerable degree of local judgment in the making of decisions and of flexibility in the use of grant funds; in this way, they permit the grantee institutions to meet some of their particular needs in science and to take advantage of some of their unique capabilities.

The purposes of the three programs are similar, although those of NIH and NASA are necessarily tied to health-related and space-related sciences, respectively.

The purpose of the NIH institutional grants has been stated as follows:

> The purpose of the general research support grant is to provide funds on a continuing basis to eligible institutions heavily engaged in health-related research and research training for their flexible and discriminating cultivation of disciplines of science relating to health. This grant permits institutions an increased measure of control over the quality, content, emphasis, and direction of their research activities. It permits them to meet emergency opportunities in research, to explore new and unorthodox ideas, to recognize and support scientific talent earlier, and in general, to utilize funds flexibly and in ways that will be catalytic for fostering additional research capabilities and for attracting additional means of research support. ("General Research Support: A General Policy and Information Statement," pt. 1, revised September 1963, National Institutes of Health, p. iii.)

The Director of NASA's Office of Grants and Research Contracts has described the purpose of the NASA sustaining university program as follows:

> The sustaining university program has been designed as an integrated program encompassing the support of training, research, and research facilities in a manner that will augment and complement sponsored project research and in-house activity in support of NASA's mission. We consider it essential to develop a strong, mutually interdependent relationship between NASA and the universities in working to fulfill the needs for scientific manpower and research in the Nation's space program. (T. L. K. Smull, "The Nature and Scope of the NASA University Program," National Aeronautics and Space Administration, 1965, p. 38.)

The announcement entitled "Institutional Grants for Science, 1965," states the purpose of the NSF program:

* * * Institutional grants * * * are intended to assist colleges and universities in the development and maintenance of strong, well-balanced programs of research and education in the sciences. Institutions may use their own judgment as to the most effective employment of institutional grant funds, with the limitations that the funds must be used for science (including mathematics and engineering) and may not be expended for indirect costs * * *.

The Foundation recognizes that institutions of higher education are in a position to determine the best means for strengthening their scientific programs. Accordingly, responsibility for the administration of an institutional grant for science rests with the grantee institution. The Foundation wishes to avoid any action that might diminish the autonomy of the institution and its responsibility for making sound scientific and administrative judgments * * *.

* * * The funds may be used for scientific research, for education in the sciences, or for both. Existing activities may be supplemented or new ones initiated with the funds made available by the grants.

Some differences in the three programs arise not only from the differing missions of the agencies but from the types of institutions to which they make their institutional grants. Most NIH grants of this nature are made to educational institutions in the "health-professional school" category (apart from certain noneducational institutions which also receive general research support grants); thus, several general research support grants may be made to component parts of a single university. NASA's grants under the sustaining university program are made to large and small universities with graduate programs. NSF's institutional grants are made to colleges and universities (513 during the years 1961–65), many of them liberal arts institutions granting only baccalaureate degrees; medical and other health-professional schools that are parts of universities and 2-year extension centers of universities are not separately eligible for NSF institutional grants.

The budget for the NSF program is much smaller than that of either of the other two agencies. In fiscal year 1965 the budget for NIH's general research support program was approximately $44 million; for NASA's sustaining university program, $46 million; for NSF's institutional grants program, $11 million.

NIH's general research support grants and NSF's institutional grants are computed by arithmetical formulas. The base to which the formulas are applied is for both agencies a "research" base, although since 1963 the NSF base has included grants under two NSF research-participation (i.e., educationally oriented) programs as well as NSF grants for research projects. The NSF formula favors "small" institutions by dollar-for-dollar matching of the first $10,000 of the base, by tapering the formula thereafter, and by setting an upper limit on the total amount of the grant. The NIH formula also has been based in part on the principle "that institutions with small research programs should receive relatively greater general research support than those with more extensive research activities." ("The General Research Support Program of the National Institutes of Health: A Report of a Study by a Committee of the Division of Medical Sciences, March 31, 1965," National Academy of Sciences—National Research Council, p. 18.) NIH also fixes an upper limit for its general research support grants, although the maximum has been substantially higher than NSF's. (The maximum NSF grant in-

creased from $37,500 in 1961 to $150,000 in 1964; in 1965, the largest grant was for $146,624. The maximum NIH grant was $452,000 in 1964 and $585,000 in 1965.)

One important difference between the two formula-grant programs is the nature of the "base." NSF institutional grants have been computed from a base made up of the total of NSF grants for basic research, undergraduate research participation, and research participation for college teachers to an institution during the 12-month period ending March 31. NIH, however, has based its general research support grants on health-related research expenditures by institutions from funds derived from "Federal research grants and contracts restricted for research" and from funds derived from "non-Federal grants, contracts and gifts restricted for research." Two different formulas are applied to these different (Federal and non-Federal) elements of the base, with the heavier weighting being given to the non-Federal portion. Four types of health-professional schools (medicine, dentistry, osteopathy, and public health) are automatically eligible for base grants of $25,000. Other types of health-professional schools, as well as separate research institutes, laboratories, hospitals, etc., may qualify for general research support grants if they have received a minimum of $100,000 of NIH research grants during the 12-month period ending June 30; only educational institutions may qualify for the base grant of $25,000.

Thus, the NSF base has been made up only of NSF grants. The NIH base consists not only of expenditures from NIH research grants but from those of other Federal agencies (including NSF) and non-Federal research grants.

NSF institutional grant funds may not be spent for indirect costs. Until 1965 the NIH general research support grants contained an allowance for indirect costs expected to be incurred by institutions in the conduct of research and research training under the grants. (This allowance was 15 percent of the basic award in the first year of the program, 20 percent thereafter.) In authorizing funds for the 1965 NIH program, however, Congress prohibited payments for indirect costs in the general research support program.

Both the NSF and the NIH grants allow a great deal of flexibility in the use of funds. Both agencies, of course, require reports from institutions on the use of grant funds, and these reports are carefully scrutinized to see that institutions have used the funds for allowable purposes.

II. PRIVATE SECTOR SUPPORT

The second question posed in E–25 might be rephrased to read: "Is support provided to institutions by private individuals, foundations, industry, etc., in the form of flexible-use institutional grants for science?"

Within the private sector, private philanthropic foundations—including company-sponsored foundations—and voluntary health agencies grant unrestricted funds for the overall development of universities and colleges. Grants of this type from these organizations are not strictly comparable to the NIH and NSF "institutional grants" described above, since they are not based on percentage formulas such as overall support of certain research and science education programs

in educational institutions. Also, unrestricted grants by private foundations and voluntary health agencies are extended for the general development of universities and colleges and may be used for any purpose that will advance educational aims, such as construction of facilities, research, and studies in all educational fields. Some of these unrestricted grants are in the form of matching funds where the educational institutions are required to match the grants in various ratios with funds raised from other sources.

Although exact data are not available for the total amount of unrestricted grants extended by private foundations and voluntary health agencies to universities and colleges, it is estimated that this amount was probably somewhat in excess of $50 million in 1964. This estimate does not include the funds given to universities and colleges by private individuals and industrial firms for the general support of education.

E-26. How does the Federal Interagency Committee on Education operate? How often has it met? What policy issues has it studied and acted upon?

Since the Federal Interagency Committee has met only once, it is not possible at this time to describe its mode of operation. It has begun to study Federal expenditures in education but has not discussed or acted upon any policy issues.

It is probable that the Federal Interagency Committee will not really get into action until an executive secretary (or equivalent) can be recruited. I understand that Commissioner Keppel is currently seeking a suitable person to assume this role.

F. National Research Programs of NSF

F–1. How does a project achieve the status of a national research program?

A national research program receives this designation where the Director of the Foundation, with the concurrence of the National Science Board and the Bureau of the Budget, specifically requests funds for its support from the Congress. If funds are then appropriated which may be used for the program, it comes into existence as an operating entity. Much planning and preliminary research may be supported prior to this time, but the major effort is not initiated until funds have been appropriated for the budget year in which the newly proposed activity is presented to the Congress.

F–2. Many of the programs which NSF supports originated in the National Academy of Sciences. Can you trace by explicit examples—i.e., the antarctic research program, Project Mohole, international upper mantle project, International Years of the Quiet Sun, and the International Biological Year—the manner in which proposals were reviewed by the Foundation, the Science Board, PSAC, OST, and the Bureau of the Budget, up to the time they were included in submissions to the Congress?

Many different groups have been interested in the development of programs, such as the antarctic research program, Project Mohole, International Upper Mantle Project, International Years of the Quiet Sun, and the International Biological Year. In most of these instances ad hoc or special committees of the National Academy of Sciences considered the needs and opportunities in these areas of science. As a result, the Academy has had an important impact on many of the Foundation's programs. This is particularly true of programs calling for a major national and interdisciplinary effort on the part of the scientific community. These committees issued reports which presented the nature of the problem from a scientific point of view and also provided estimates of funds which would be required in order to carry them out. These reports were in most cases sent or submitted to the Foundation and to the Office of Science and Technology. In reviewing these reports, the Director has of course had the advice of the National Science Board, and (since 1958) has been able to confer on such matters with the Special Assistant to the President for Science and Technology. As a result of these coordinative efforts, and if it was agreed that a proposed program held great promise, the fiscal needs for such a program were placed before the Bureau of the Budget. After review by the Bureau and approval of funds by the President, the program was begun. In the following examples an effort is made to trace the origin, development, and management of several such programs.

ANTARCTIC RESEARCH PROGRAM

The program for the International Geophysical Year (IGY), for which the National Academy of Sciences held a major degree of responsibility, included a research effort in Antarctica. Recognizing that the period set aside for the IGY was insufficient for the accomplishment of the scientific objectives in Antarctica, the Academy recommended to the Foundation that the program be continued for at least an additional year. Concurrently, the U.S. Government, aware of these recommendations, reviewed the commitment the United States had in Antarctica. An Executive decision was made in 1957 to continue U.S. activities in Antarctica on a long-term basis. It was further decided at the Executive level that the National Science Foundation would assume the responsibility for planning, coordinating, and funding an integrated research program in Antarctica with the Department of Defense funding and supplying the necessary logistic support. (In toto, the actual magnitude of the Department of Defense contribution is greater than that of the Foundation.)

On January 24, 1958, the Director of the Foundation, in testimony before the House Committee on Interstate and Foreign Commerce, announced the plan to continue U.S. antarctic scientific programs beyond the IGY. Similar announcements were issued by the White House and the Department of the Navy. On February 5, 1958, the National Academy of Sciences responded to the Foundation's request of January 17, 1958, for advice in developing a comprehensive antarctic research effort by establishing the Committee on Polar Research, chaired by Dr. Laurence M. Gould.

Correspondence was simultaneously exchanged between the Director of the Foundation and the Secretaries of Commerce, Interior, and Defense establishing concurrence that the Foundation go forward to obtain a single budget and appropriation for the support of the "post-IGY" program. The budget initially suggested by the Academy to the Foundation was $4.3 million, but because of policy and the limitation on logistic support that the U.S. Naval Support Force, Antarctica, could provide for the scientific program in the coming year, the Foundation reduced the budget estimate to $2.435 million and a request for a supplementary appropriation was submitted to the Congress.

The House Committee on Appropriations, in considering the bill, struck out the entire amount, which the Senate restored. On May 12, 1958, the conference committee approved $2 million for the entire research program, $1 million of this amount to be new money appropriated by Congress and the remaining $1 million to be absorbed by the Foundation from its regular 1959 appropriation.

Subsequently, the interagency arrangements for the planning and management of the U.S. antarctic research program were formalized by issuance of the Bureau of the Budget Circular A–51 of August 3, 1960 (see the response to question F–8).

Within the Foundation, the responsibility for handling the organization of the antarctic scientific program (and its coordination with the logistic operations of the U.S. Naval Support Force, Antarctica) was assigned to the antarctic program in the Office of Special International Programs. The management authority for U.S. scientific activities in Antarctica was thus transferred from the Academy to

the Foundation. Subsequently this unit in the Foundation became the Office of Antarctic Programs.

The Committee on Polar Research of the National Academy of Sciences continues to provide the Foundation with recommendations on broad program content and undertakes from time to time specific tasks of an advisory nature related to antarctic scientific exploration. In 1961 the committee prepared and submitted to the Foundation a long-range analysis of scientific objectives (NAS-NRC Publications 839 and 878). The committee also represents the Academy and the U.S. scientific community with antarctic interests on the Scientific Committee on Antarctic Research of the International Council of Scientific Unions.

PROJECT MOHOLE

The Mohole project was proposed by the National Academy of Sciences. The first proposal in March 1958, called for a feasibility study and, during that year, the Foundation granted funds for such a study. The work was done by the Amsoc committee—the official Academy committee formed to carry out the project—and its staff. This initial study provided data and information which demonstrated that with current advances in technology and with some adaptation of existing drilling equipment, it might be feasible to drill through the crust of the earth and sample the underlying mantle.

With funds provided by the Foundation, the Academy assembled a staff, and phase I of the project was successfully carried out. Phase I concluded with the drilling of several shallow holes into the Pacific Ocean floor in water approximately 12,000 feet deep from a dynamically positioned oil drilling barge. Cores were recovered from beneath the ocean floor providing material for new scientific studies. Several scientific and technical papers resulted.

When the plans to carry out phase II of the project were formulated—the actual attempt to drill through the crust—the Academy committee recommended that this phase be carried out directly by the National Science Foundation under contract. The contract would provide for the entire effort—management, engineering research, development and design, and operations. The project has proceeded in this manner.

The Mohole project from the beginning has received the attention of the Director of the National Science Foundation and his top staff. In its conceptual stage, the project was carefully considered by the National Science Board and the President's Science Advisory Committee. Every major step in the project has been reviewed with the National Science Board, and no funds have been obligated without first obtaining the Board's authorization. Reports have been made to the Bureau of the Budget in the course of the regular budgetary process, and special reports have been made to the Bureau of the Budget and the Office of Science and Technology in working out funding pursuant to the sense of the conference report accompanying the fiscal year 1964 appropriations act.

THE INTERNATIONAL UPPER MANTLE PROJECT

The international upper mantle project originated not at the National Academy of Sciences but in the International Union of Geodesy

and Geophysics. It was proposed by Academician V. V. Beloussov of Russia at the 12th General Assembly of the Union at Helsinki in 1960. A resolution was passed endorsing Beloussov's suggestion, and scientists from various member countries started planning for the work.

In the United States the National Academy is the adhering body for international scientific unions. The Academy, therefore, through its Geophysics Research Board, set up a panel to outline a realistic program for the U.S. participation. The plan, which was issued in 1962, recommended a program for the U.S. participation in the upper mantle project that would involve work by the U.S. Geological Survey, U.S. Coast and Geodetic Survey, Advanced Research Projects Agency through its Vela program), and universities. It was recommended that the universities seek support for their work from the National Science Foundation.

Strictly speaking, the upper mantle project has never been formally declared a national program, although both the present and previous administrations have endorsed the activities connected with the project. The Foundation has never received a proposal for funds simply to "support part of the upper mantle project." Instead, various university projects that are considered to be part of the U.S. effort are submitted as regular research proposals to the Foundation and compete with all other research proposals in the earth sciences. In other words, there is no special sum allocated by NFS for use in support of the upper mantle project, and every successful proposal must be judged worthy of support in competition with other research proposals received by the Foundation in order to receive a grant.

Activities in connection with upper mantle studies have been cited in our budget request, but no line item has been sought.

INTERNATIONAL YEARS OF THE QUIET SUN

The International Geophysical Year (IGY), and the following International Geophysical Cooperation (IGC), taking place during a solar cycle maximum of unique intensity, revealed unexpected and challenging phenomena that clearly demonstrated the need for a specific coordinated program of special scientific research during the subsequent solar minimum; as a consequence, interested scientists proposed the International Years of the Quiet Sun (IQSY). The period was set as the 24 months beginning January 1, 1964.

In recognition of the international nature of this task (and because of the consequent need for a national group to coordinate U.S. efforts with those of other nations), the National Academy of Sciences established the U.S. Committee for the IQSY to accomplish the planning of the scientific programs. In early 1962, the National Academy of Sciences wrote to NSF seeking formal Government concurrence on the merit of the IQSY research programs.

An extensive and detailed staff analysis and review of the IQSY was undertaken within the Foundation which resulted in the decision to accept the program on behalf of the Government and to seek the formal endorsement of the President for the U.S. participa-

tion. The Foundation on July 27, 1962, wrote to the President in part as follows:

In view of the substantive values to be derived from this program and in view of the opportunity it affords the United States to promote international cooperation and to exercise international scientific leadership, the National Science Foundation recommends your endorsement of U.S. participation in the program for the International Years of the Quiet Sun. With such endorsement, and subject to appropriate program and budget review, the Foundation stands ready to include in its budget request the estimated funds required, to coordinate the Government's interests in this program, and to make arrangements with appropriate Federal and other agencies for carrying out the program.

President Kennedy responded with an authorization and emphasized the importance of NSF taking responsibility and leadership in developing the additions to the normal agency programs and in maintaining control over the size of the effort.

Concurrently with the NSF staff review the Interdepartmental Committee for Atmospheric Sciences (ICAS) formally considered Government participation in the IQSY program. ICAS recommended the program to its parent body, the Federal Council for Science and Technology.

Following receipt of the President's letter authorizing participation in the IQSY, a memorandum was prepared for the consideration of the National Science Board. It summarized the background and the scientific program of the IQSY and estimated the fiscal requirements as follows:

Fiscal year 1963	$1,000,000
Fiscal year 1964	5,000,000
Fiscal year 1965	5,000,000
Fiscal year 1966	1,000,000
Fiscal year 1967	1,000,000
Total	13,000,000

At its meeting of November 17, 1962, the National Science Board approved the U.S. program for the International Years of the Quiet Sun and delegated to the Director authority to review, approve, and take final action with respect to making grants, contracts, or other arrangements not to exceed $13 million for the purpose of providing support for the U.S. program for the IQSY.

Formal request to the Bureau of the Budget for support of IQSY as a national research program was first made in the NSF budget request for fiscal year 1964. Review by the Bureau of the Budget took place in connection with that request.

THE INTERNATIONAL BIOLOGICAL YEAR

The International Biological Year has officially become the international biological program. When it became evident that relatively little biological research was to be included in the activities associated with the International Geophysical Year (IGY) (1957–58) and the International Geophysical Cooperation (IGC) (1959), sentiment developed among a few individuals for a similar—large, varied, and

international—biological program. At first there was no great enthusiasm among working-level biologists for participation in such a movement. But a number of groups continued to advocate such an activity, and interest slowly increased.

Meanwhile the problem had been discussed by the Executive Committee of the International Union of Biological Sciences (IUBS) at their annual meetings in 1959 and 1960 and by the Executive Board of the International Council of Scientific Unions (ICSU) in the spring and fall of 1960. A proposal for organization of a biological year similar to the IGY was proposed by Prof. G. Montalenti of the Institute of Genetics, University of Rome, then president of IUBS, to ICSU which approved it in principle in October 1960. Members of the U.S. National Committee to IUBS were at this time involved in discussions of the matter.

The idea was then considered further by members of ICSU and three of its affiliated unions: the International Union of Biological Sciences; the International Union of Biochemistry; and the International Union of Physiological Sciences. At its general assembly in 1961, ICSU approved a revised version of the Montalenti plan for an international biological program, and formed a planning committee. The IBP Planning Committee held two meetings in May 1962 and January 1963 from which a general plan for the IBP emerged. Three subcommittees were also set up to facilitate planning. ICSU provided housekeeping funds for the IBP secretariat and committees. The aim was to have a final plan ready for consideration by the IUBS General Assembly in Prague in August 1964.

The National Academy of Sciences involvement dates back to IUBS involvement. NAS–NRC coordinated with and thus kept NSF advised of the course of this activity. The Academy gave NSF an opportunity to comment on the proposed selections for the ad hoc committee for the IBP it was setting up to consider U.S. participation. NSF was also invited to have observers at all meetings of this ad hoc committee and to send an observer to Paris in July 1964 at the time of the first general meeting called by ICSU to consider IBP. At Paris, the organization of the IBP was formalized. The ad hoc committee for IBP, which carried the U.S. point of view to Paris, recommended to NAS upon its return that the United States participate in the IBP. NAS accepted the recommendation and appointed a new U.S. committee for the IBP to plan and coordinate U.S. participation. NSF has monitored all these preliminaries.

From the time of the first mention of a possible large international biological program, NSF closely followed this development as it recognized it might well be approached for financial assistance. The Foundation's interest centered on the soundness of the scientific program, its feasibility, the strength of its leadership, the breadth of its appeal, and the likelihood of obtaining funds for its support. Since fiscal year 1963 NSF has been concerned with the amount of support it might be called upon annually to provide for the IBP. Through the National Academy of Sciences, NSF has provided the annual dues for U.S. participation in the IBP since they were set in 1964 and it has made the major contribution (NIH has provided the rest) toward support of the U.S. committee and subcommittees involved in planning for the IBP.

Reference was made to the IBP in our fiscal year 1966 budget justification to the Bureau of the Budget and Congress, but no special funds were requested. Any funding for IBP-related activities through fiscal year 1967 will be handled with research funds from the Foundation's project grant funds. Special budgetary treatment (akin to that for other "national research programs") may become unavoidable in fiscal year 1968 at which time the IBP will become fully operational.

Meetings called by the National Academy of Sciences in connection with the IBP have included observers from such other governmental departments and offices (in addition to NSF) as State, Interior, Agriculture, NIH, ONR, AEC, NASA, OST, etc. No one agency has as yet been assigned the overall responsibility for the IBP as is customary for international programs.

Within NSF the IBP has been discussed with the National Science Board on several occasions as well as with the Divisional Committee for Biological and Medical Sciences. At the April 1965 meeting of the latter committee, the IBP was featured on the agenda and the possible role of the NSF in the IBP was considered in depth.

F-3. What is your reaction to the series of reports and recommendations by the National Academy of Sciences with respect to needs for research in special fields?

The reports undertaken under the auspices of the Academy's Committee on Science and Public Policy promise to serve as extremely valuable sources for data and judgment and to contribute to sound policy decisions. I am pleased that the Foundation has been able to play a major role in making these reports possible by financially supporting much of the work of the Committee on Science and Public Policy. One of these reports was published last year by the Academy, that on "Ground-Based Astronomy: A 10-Year Program." Reports on chemistry, computers, and physics are scheduled for publication in the near future. Another on plant sciences has moved a long distance toward completion, and studies of mathematics and biology are being launched.

Prepared with the guidance and under the scrutiny of the Committee on Science and Public Policy, these reports represent a new stage in efforts directed toward the rational planning of longer range science policy. They can and will help illuminate for the entire scientific enterprise—including especially the Federal Government, and, therefore NSF—many problems of the short- and long-term policy with respect to research and education in the sciences. In addition, these reports offer promise in developing interagency approaches to problems of funding and program evaluation. Thus, they can assist in assuring the future health of fields of scientific activity.

It is worth noting that the involvement of significant numbers of scientists in the panel structure used to prepare these reports adds an additional dimension to their worth which is commonly overlooked. Those so involved are inevitably brought to a better understanding of both the nature and problems of science policy and of the relationship of academic research to the Nation's total scientific enterprise.

I would only note that these reports, valuable as they have been and will be for planning future needs in the scientific field that each covers, as yet provide no basis for comparisons of the relative urgency

of meeting the needs of the several fields. This problem is of continuing concern to the Foundation whose responsibilities cover the broad spectrum of the sciences.

F-4. What was the reason for assigning the weather modification program to NSF, in the 1958 amendment to the basic NSF Act, rather than to some other Government agency?

In 1953, pursuant to an act of Congress, the Advisory Committee on Weather Control was established. It consisted of the Secretaries of the Departments of Agriculture, Commerce, Defense, Interior, HEW, and the Director of the National Science Foundation (or their designees), as well as five private members appointed by the President, by and with the advice and consent of the Senate. The Committee was directed to make "a complete study and evaluation of public and private experiments in weather control for the purpose of determining the extent to which the United States should experiment with, engage in, or regulate activities designed to control weather conditions." The Advisory Committee on Weather Control rendered its final report on December 31, 1957. In the light of its study and evaluation of the public and private experiments in weather control undertaken during the 4 years of its activities, it concluded that progress in weather modification would have to rest on a firmer foundation of knowledge developed through basic research into the physical and chemical processes of the atmosphere. The Committee recommended unanimously that the Foundation, as the agency of the Federal Government responsible for supporting general-purpose basic research, should assume responsibility for the program. The Congress, with this report before it, then enacted the 1958 amendment to the NSF Act. I believe that the ongoing programs of the Foundation, together with a recognition of its close relationship with the scientific community, also were considerations which entered into the decision of the Congress.

F-5. Apart from grants for research in weather modification, what has been the Foundation's involvement in this field since 1958, relative to private and other nongovernmental operations? Does NSF plan to expand its activities in weather modification research?

Other than through its research support, the Foundation has not become involved in private or nongovernmental operations in weather modification, although NSF does require reporting of actual seeding activities to the NSF in accordance with its reporting and evaluation responsibilities under Public Law 85-510. Private industrial research groups have successfully competed for NSF weather modification research funds and are awarded contracts for the scientific research and special studies thus performed. In addition, the Foundation has sponsored technical symposia and individual travel to foreign scientific meetings in which members of private or nongovernmental groups have participated. The NSF does not plan to assume any regulatory or coordinative function with any private or nongovernmental group since such authority is not given under Public Law 85-510 and is not consistent with the Foundation's mission in research and education. The NSF will, however, shortly require any individual or organization, whether commercial or nonprofit, to report to it in advance any plans for field activities to modify the atmosphere and will require monthly progress reports during the conduct of such field operations.

With regard to budget plans, the Foundation increased its allocation of funds for weather modification research from $1.5 million in fiscal year 1964 to $2 million in fiscal year 1965. It is planned that the $2 million level will be held during fiscal year 1966. Hopefully, the level will be increased in fiscal year 1967. Indeed, we foresee a need to substantially increase the Foundation's budget for weather modification research in future years; however, I believe that determination of the scale of this increase should await the report of the Foundation's Special Commission on Weather Modification which is now considering this entire problem.

F-6. A recent report of the Government Operations Committee stated that the current status of coordination of weather modification is not clear, and that both the NSF and Interdepartmental Committee for Atmospheric Sciences of the Federal Council for Science and Technology claim coordinating responsibility. Would you explain the relative coordinating responsibilities of each? What are the duties of each insofar as the evaluation of research is concerned?

The National Science Foundation does not claim program coordination responsibility in weather modification, since this authority was not conferred on the Foundation by the act of July 11, 1958, Public Law 85-510. The act especially directs the Foundation to "initiate and support a program of study, research, and evaluation in the field of weather modification * * *." As its first task, the Foundation undertook the encouragement and the building up of the widest possible competent research in the fields of meteorology related to weather modification, such as laboratory cloud physics, experimental cloud physics, including the use and development of cloud seeding techniques, and the design and evaluation of weather modification experiments through use of advanced principles in statistics and physical meteorology.

Therefore, under the authority of the act, the National Science Foundation assumed a leading role in the support of weather modification research. The research is accomplished by contract with or by grant to private or public institutions. The Foundation also consults with meteorologists and scientists within Government agencies and outside the Federal Government who are interested in or affected by weather modification research. Several of the Federal departments and agencies also conduct weather modification research projects that bear directly upon their statutory missions.

The act also requires the Foundation to submit an annual report on weather modification to the President and the Congress. In order to obtain the necessary detailed technical information on the progress of research sponsored by other Federal agencies, the National Science Foundation convenes the Interagency Conference on Weather Modification each year, which is attended by working level research scientists and research administrators. The Conference leads to an evaluation of the progress made on the research projects of each participating group, and the working scientists are encouraged to enter into joint project relationships and share the technical facilities and capabilities across departmental or agency lines on a voluntary basis. Proceedings of the Interagency Conference on Weather Modification are distributed to the Conference attendees. Elements are abstracted

for insertion in the annual report on weather modification to the President and the Congress prepared by the Foundation.

The Interdepartmental Committee for Atmospheric Sciences has the responsibility to coordinate all of the atmospheric sciences, including weather modification research. ICAS is attended by policy level persons and coordination is accomplished at the program and budget review level across the departmental and agency lines. ICAS initiates studies on national requirements in areas of the atmospheric sciences and recommends the initiation or modification of programs through the Federal Council for Science and Technology. ICAS does not conduct a detailed project-by-project review, such as that undertaken by the Interagency Conference on Weather Modification.

With regard to evaluation, the NSF fully evaluates all research projects which it considers for support, including requests for transfer of funds to support other Federal Government projects in weather modification. The evaluation process continues for the duration of the support period. ICAS, on the other hand, evaluates programs and policies in weather modification on a broad Federal level in connection with its budgetary review procedures and the coordination of atmospheric sciences programs.

F–7. Does the Foundation coordinate, or is it aware of, the activities of commercial weather modification firms? Is the Foundation planning to expand its activities in this area? Suppose some of these commercial firms do not wish to cooperate with the Foundation, has or would the Foundation use its subpena powers set forth in section 14(f) of the NSF Act?

Under the provisions of Public Law 85–510, the NSF is directed, "to initiate and support a program of study, research, and evaluation in the field of weather modification * * *." Since coordination would require the power to regulate or deny permission to a cloud seeder to perform the services for which he has been hired by his sponsor, the NSF does not interpret the coordination of the activities of commercial weather modification firms as being implicit in the authority to evaluate their activities. The Foundation does require that each commercial cloud seeder report his activities to the NSF upon completion of the field operation using a BOB approved form, 9B–13, supplied by the Foundation. These records have been maintained by the NSF on a yearly basis since 1959.

The Foundation is preparing a regulation for issuance under the authority of Public Law 85–510 which will require all weather modifiers, whether Government, university, or privately supported, to report to the NSF their intention to seed or otherwise modify the weather prior to actual field operations and to report their operations to the NSF every 30 days during the field operational period. In addition, the regulation will require that each seeder maintain a written log for a stated period of years, and that this log be made available to the NSF upon demand during that period. In event that any cloud seeder refuses to comply, the Foundation is prepared to invoke the subpena powers set forth in section 14(f) of the NSF Act if such action appears appropriate.

F–8. In the Antarctic research program, the NSF maintains a 266-foot research vessel and four mainland stations. Does the Foundation operate those under contract with an outside group? If not, does this

conflict with section 15(c) of the NSF Act, which provides that "the Foundation shall not, itself, operate any laboratories or pilot plants"?

By executive agreement, prior to the initiation of the International Geophysical Year, the principal logistic support for the construction and operation of Antarctic stations was assigned to the Department of Defense and delegated to the Secretary of the Navy. The responsibility for directing the scientific programs rested in the National Academy of Sciences. Under Bureau of the Budget Circular A-51, dated August 3, 1960 (copy attached), the Department of Defense continues to bear the responsibility for logistic support, including station operation, with the Foundation responsible for the scientific programs.

The Antarctic stations, Byrd, McMurdo, Palmer, and Pole, are operated and maintained by the U.S. Navy by executive agreement, as noted above. The Foundation does not operate these stations. The research at these stations is carried on by university and agency scientists under grant or transfer of funds from the Foundation. In the case of the *Eltanin*, the ship is operated for the Foundation by the Military Sea Transportation Service and the scientific programs aboard are, in the same manner as at the stations, carried out under grant or transfer arrangements between the Foundation and university or agency, as appropriate.

At the stations on the continent and on the *Eltanin*, certain phases of the support to the scientists and the maintenance of specialized laboratories are performed under contracts with organizations experienced in these matters.

(BOB Circular A-51.)

[Circular No. A-51]

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D.C., August 3, 1960.

To: The heads of executive departments and establishments.
Subject: Planning and conduct of the United States program for Antarctica.

1. *Purpose.*—This circular provides the basis for the planning, budgeting, management, and conduct of the United States program for Antarctica.

2. *Policies.*—The following general policies are to be observed by the Federal agencies concerned:

(*a*) The National Science Foundation shall continue to exercise the principal coordinating and management role in the development and carrying out of an integrated U.S. scientific program for Antarctica. Agencies shall cooperate with the Foundation in this regard through the appointment to advisory committees of policy level or other agency representatives as may be requested by the Director of the National Science Foundation.

(*b*) The Department of Defense shall continue its role with respect to the planning and carrying out of operations in support of the scientific or other programs in Antarctica. The commander of the military support force shall continue to be the senior U.S. representative in Antarctica. He shall have reponsibility for determining the feasibility of, and insuring the success and safety of, Antarctic operations while making all reasonable efforts to provide the support necessary to fulfill the objectives of the Antarctic programs.

(*c*) While no central depository for Antarctic records is required, the National Science Foundation shall serve as the clearinghouse and source of information regarding the existence and location of Antarctic records, files, documents, and maps maintained within the various executive agencies and nongovernmental organizations.

3. *Role of the Operations Coordinating Board in the overall review of Antarctic activities.*—The Operations Coordinating Board serves as the coordinating agency for the totality of Antarctic activities and reviews each year's operations plan for Antarctica on a schedule coordinated with the budget cycle.

4. *Relations of the National Science Foundation to other organizations in the planning of an integrated U.S. scientific program for Antarctica*—

(*a*) The Director of the National Science Foundation may consult with interested Federal agencies and with non-Federal organizations, to the extent he considers desirable, in the development by the Foundation of an integrated U.S. scientific program for Antarctica.

(*b*) Federal agencies interested in scientific activities for Antarctica, either to be conducted by their own staffs or by other agencies and personnel, should inform the National Science Foundation of their interest and of the content of proposed scientific activities that might be included in the U.S. scientific program to be developed and funded by the Foundation.

(*c*) The National Science Foundation shall advise the Department of Defense as to its plans for scientific programs for Antarctica in sufficient time and in sufficient detail for the Department of Defense to develop the required supporting program on an orderly basis. The Department of Defense shall, in consultation with the National Science Foundation, develop a logistic program to support the U.S. scientific program for Antarctica.

(*d*) The Foundation shall continue to make allocations to Federal agencies and grants and contracts to non-Federal organizations, as it considers appropriate, to carry out the U.S. scientific program for Antarctica.

5. *International cooperation in Antarctic programs.*—The National Science Foundation, in consultation with the Department of State, shall coordinate and arrange for the conduct of cooperative scientific programs with other nations participating in the Antarctic.

6. *Budgeting and financing of Antarctic activities*—

(*a*) The National Science Foundation shall continue to plan for and request all funds for an integrated U.S. scientific program for Antarctica, including such mapping activities as are related to the scientific program, but excluding logistic support as provided for below. The Foundation shall continue to present each year to the Bureau of the Budget as an identifiable part of its regular budget submission its recommendations as to the content and cost of the U.S. scientific program for Antarctica.

(*b*) The Department of Defense shall continue to fund the logistic support for scientific and other Antarctic activities. The Department shall present each year, as part of its budget submission to the Bureau of the Budget, a statement covering the estimated costs of its support of the Antarctic operation. This statement shall cover the past, current, and budget years.

By direction of the President:

MAURICE H. STANS, *Director*.

F–9. What is the objective of Project Mohole and what benefits will be achieved by the successful completion of the project? What is the present status of the project?

F–10. With regard to Mohole, (a) When do you expect the successful bidder on construction of the platform to be announced? (b) What are Foundation's plans and prospects for having scientific guidance of the project moved outside of the Foundation? (c) In view of the increasing estimates of cost recently submitted to the Senate, is the Foundation considering a review of the merits of this project against other scientific programs of possibly higher priority?

F–11. Some of the technical problems which have affected the Mohole project are the stabilization of the drilling platform, achieving a means of getting the drill back in the hole after it has been removed, and the reduction of forces exerted on the drill string. (a) What success has been made to date in solving these problems? (b) What is the greatest depth to which deep sea drilling has been successfully demonstrated to date? (c) What depth will be required to pierce the mantle?

F–12. When the mantle of the earth is pierced, what will then become of the project? When is the project expected to be completed?

F–13. To date, what has been the total amount appropriated and the total amount expended for Project Mohole, including both phase I

and phase II? (a) What is the total estimated cost of the drilling platform including equipment? (b) What is the estimated total run-out cost of the project up to the time the mantle is pierced?

Because these five questions are so closely related, I have attempted to provide in what follows an integrated discussion which, we believe, deals with each of the points raised.

While it is well known that the most difficult objective of Project Mohole is to drill through the earth's crust and on into the next region called the mantle, we consider this project as but one aspect of a program with a much broader aim of exploring the sea floor by deep drilling in as many of the world's oceanic regions as possible. Drilling to the mantle is a difficult engineering feat. For this and other reasons this aspect has caught the attention of the public and has tended to dominate the "image" of the program as a whole.

Placing the program in its proper perspective, we may state that the Mohole project will lead the way toward opening the deep portions of the earth to the direct scrutiny and analysis of scientists. Because it will be an engineering and scientific first, involving large and complicated equipment, it will be expensive, but it has the broad and important objective of studying the earth directly as a planet rather than as a continent or an ocean, a deep sea canyon or a high mountain peak. We are at the beginning of planetary exploration and it is important that the earth also be studied as a body in space.

Eighty-five percent of the earth lies in the mantle beneath the crust. By studying and understanding the mantle, the forces at work there, its chemical composition, its age and, hopefully, its origin, we can for the first time truthfully say that we are beginning to understand the earth. It is this understanding that the Mohole program through years of work will eventually bring about.

Since we eventually hope to sample the mantle, perhaps in several places, the work must be done at sea where the crust is thin enough to penetrate. With this aim in mind there has been designed a large, stable, free-floating drilling platform that will maintain its position without anchoring in very deep water (as much as 18,000 feet) for long periods of time—as much as 2 to 3 years. The required accuracy of position cannot be achieved by anchoring at such depths.

Thus the present phase of the project should be thought of as one in which we are attempting to design and construct a major facility capable of drilling to great depths, including reaching to the mantle. Once acquired, this facility will be used as a research tool for many, many years, and merely, as many people erroneously suppose, to drill a single hole.

The benefits to be achieved by the program, so far as we know them today, are largely scientific. However, there are engineering benefits that will undoubtedly result.

So far as science is concerned, first we hope to obtain a better determination for the age of the earth since the mantle comprises 85 percent of the volume. Current age determinations are made from surface rocks which make up less than 1 percent of the earth's volume. Second, the old geologic question of whether the continents have drifted apart may be also partially answered by sampling the crust under the deep sea. If a thick section of sedimentary rocks is found beneath the sea, we can say that the ocean basin has been present for as long

as the sediments are old, and that the continents may not have drifted by sliding over the mantle's surface. Third, we hope, as well, to determine the chemical and physical nature of the mantle. The distribution of the elements in the earth and the surrounding universe is of prime interest to astrophysicists, geochemists and geophysicists. Scientists in these fields and others have always been interested in the origin of the planets and the universe and look for their clues in the physics and chemistry of nature. Basic to this is the distribution of the chemical elements in the earth and universe, how they are combined, and how the elements are made by new and evolving stars. The best base the scientists have from which to work is their knowledge of the earth, and they do not know the distribution of the elements in the mantle or in what way they are combined there. Thus our yardstick—the earth—for measuring the distribution of the elements in the universe is inadequate. Fourth, the related sciences of biology and paleontology will also benefit from sampling continuously through the sediments of the sea, however thick they may be. It is hoped that remnants of previously unknown early forms of life will be discovered that will fill in some of the gaps in our knowledge of the evolution of life on this planet. Fifth, there are, in addition, many other scientific benefits of equal importance that will derive from the project. The density of deep crustal and mantle material may be directly related to the speed of propagation of seismic waves and to gravitational accelerations. The rate of heat flow from the earth can be measured in the mantle, and further clues obtained on the origin of the heat. Information will be collected on the rates of sedimentation, and on the processes at work that form hard rocks out of sediments. Last, but not least, from all such studies will come information that will help to determine the origin of continents and, hopefully, will help as well with the problem of determining the origin of the earth.

The engineering benefits to be derived from the project are straightforward. Of primary importance is the large, floating, stable platform, dynamically positioned for drilling in very deep water. This platform will have other uses besides drilling at sea. It can also be used for implanting equipment on the deep sea floor or removing it. Platforms of this type can be used for satellite and missile tracking in areas where it is impossible to install land stations. The platform can be used for almost any other type of heavy work at sea, and should be useful for all these purposes for at least 20 years. It is reasonable to discount the high cost of the platform somewhat because of its longevity and great usefulness.

Secondarily, a few examples, and there are others, of individual engineering accomplishments may be cited that eventually will become beneficial spinoffs to the offshore drilling industry: (1) the turbocorer radial thrust bearing redesign and relocation has increased the expected life of this device by about 100 percent as demonstrated by test drilling in Texas. (2) It now appears probable that a wire line retractable bit can be successfully designed for both standard rotary drilling and turbocorer drilling. This will obviate the necessity for pulling great lengths of drill stem in order to change bits, since the retractable bit can be pulled out and replaced through the hollow drill stem. (3) An automated and programed system for handling

drill pipe and casing has been designed. This speeds up the drilling operation and will result in great saving in time and reduce the danger to personnel working on the drilling platform. (4) The fabrication problems of manufacturing titanium drill stem are under study. Titanium, while more expensive, would give greater strength for weight and is not subject to salt water corrosion. If this metal can be extruded in the lengths needed, and if a method can be found for upsetting the ends and attaching the tool joints, it will be a great boon to the offshore drilling industry. (5) Research on buoyancy material has received major interest from the industry and from the Navy. Static buoys are needed to support the riser casing in deep water. A syntactic foam material using glass microspheres in an epoxy matrix has been developed which appears at the present to solve the problem for static buoyancy.

The problems of stabilization of the platform, hole reentry and reduction of forces exerted on the drill string and riser casing have all received initial solutions compatible with the design limits set. The stability of the platform is such that drilling could continue in fully developed seas with winds of 30 knots and a surface current of 3 knots. A riser casing can be designed successfully to meet any specified environmental condition, but the environment is variable and the greater the variation allowed, the greater becomes the cost. The most critical points for the riser casing are at the surface where it fastens onto the platform, and at the bottom where it enters the sea floor. It has been determined that the platform cannot move horizontally from directly above the hole for a distance greater than 500 feet without endangering the riser casing. This is about 3 percent of the water depth and is an empirical number based upon the limited experience and observation gained during the phase I operation off Guadalupe Island. There is no better number available nor can one be developed without further experience. The platform's positioning system is designed to keep the platform within this boundary, and the riser casing is designed with a "bumper sub" or telescoping joint to eliminate additional tension due to the vertical movement of the platform.

Hole reentry is solved by the riser casing which, in effect, moves the hole up to the platform. If a riser casing is not to be used during preliminary drilling, a combination of a variable jet bit and TV camera is planned to guide the bit into the hole. This combination has been tried by means of an electronic computer simulation and in this way successfully demonstrated, although the real proof has to come from actual field testing. Impinging upon the hole reentry problem is the possibility of using the retractable wire-line bit. If this is successfully developed, and the chances are high that it can be, it will mean that we will not have to pull the drill string out of the hole in order to change bits, and thus we will not have to reenter the hole so often. Indications are that the bit can be designed for either turbocorer drilling or rotary drilling.

It is hoped as well that the fabrication problems of titanium drill pipe can be successfully solved.

The anticipated tensions in the drill string have been reduced by the proposed use of the improved turbocorer. With this tool it will not be necessary at extreme drilling depths to rotate the drill string

in order to drill. Since the bit is the only rotating part when the turbocorer is drilling, this eliminates high torques that would otherwise be placed on the drill string. It further eliminates the magnus effect or lifting effect that would place additional tension on the string if it were rotated at a normal drilling speed of 45 r.p.m. The string is also equipped with "bumper subs" to eliminate tension and pounding of the bit on the bottom as a result of the vertical motions of the platform. Under emergency conditions caused by storms or high seas, the riser casing and enclosed drill string are to be simply suspended by a gimbal system and allowed to swing or, more specifically, the platform is to be allowed by the gimbal to roll and pitch about the upper end of the drill string. In extreme conditions the platform would, of course, have to be disconnected.

The deepest drilling at sea to date was that successfully demonstrated in 11,700 feet of water by phase I of the Mohole project. During normal offshore exploration for oil, rigs commonly drill in water up to 300 feet in depth and work has been done at 750 feet in a few instances.

The latest estimate of the depth to pierce the mantle at the Hawaiian site is 31,800 feet which includes 14,000 feet of sea water.

When the first successful mantle drilling is completed the platform can then be used for exploratory drilling in deep water, further drilling to the mantle in other locations for comparative purposes, and for such other heavy work at sea as many develop. It is difficult to estimate a realistic completion date for the first mantle drilling because of environmental factors, and trouble that may be normally expected in drilling deep holes. However, if all goes reasonably well, that phase of the project should be completed within 2½ or 3 years after deep drilling commences, or by 1970 or 1971.

The Foundation plans to enlist the support of a user group for scientific guidance of the project. This can conceivably be arranged within the next 2 years. (At this time two advisory committees of the National Academy of Sciences are used for scientific advice.) No formal discussions as to the future have been held on this point, but there are two groups that might be interested in considering the matter. They are JOIDES (joint oceanographic institutions for deep exploration of the sea) comprised of Columbia University, the Woods Hole Oceanographic Institution, the Scripps Institution of Oceanography, and the University of Miami and GURC (Gulf Universities Research Corp.) comprised of University of Houston, Rice University, University of Texas, Florida State University, Louisiana State University, Southern Methodist University, and Texas A. & M. University. One informal meeting has been held with the JOIDES group and it was their decision that they would not be interested in taking over the Mohole project until the Mohole platform has been operationally demonstrated and when it might be otherwise appropriate. The JOIDES group desires to gain experience in drilling at sea before making any large operational commitments. The Foundation has had one informal and unofficial visit from a representative of GURC during which their possible interest in the Mohole project was expressed.

The present status of the project can be summarized as follows: The research, development, and design work is largely completed. Subcontracts for fabrication of the positioning system and some components of the drilling system have been awarded. Requests for proposals have also gone out for additional fabrication work. Some research remains to be done on drilling fluids and additives, on some parts of the riser casing buoyancy system, and some development work remains in those areas and on the instrumentation for scientific measurements to be made in the hole.

On March 10, 1965, Brown & Root issued an invitation for bid to qualified shipyards for the construction of the drilling platform. This is much the largest subcontract contemplated on the project. Bids were received from four shipyards and were opened on July 12, 1965, the apparent low bidder being National Steel & Shipbuilding Co., San Diego, Calif., with a bid of $29,967,000. During the period between the invitation for and receipt of bids Brown & Root made a detailed reestimate of costs for the entire project. Unfortunately, these estimates are very substantially higher than the earlier ones. Also because of additional time required for design and construction of the platform, the schedule has slipped by the order of a year.

With a contingency factor of $3 million added by NSF to the estimates of the prime contract, the total estimated cost of the prime contract prior to drilling is $77 million. To state it another way, the cost of putting the drilling platform in the water ready to start the preliminary drilling program is now estimated at $77 million. This is between $25 and $30 million higher than estimates of a year ago which were, of course, based on very incomplete designs and no procurement bids at all.

Drilling operations, including the preliminary work at intermediate depths, are estimated to cost approximately $11 million per year. If present estimates of time required to pierce the mantle the first time prove to be correct, the total amount expended by that time (including preliminary drilling) is presently projected to be about $110 million. Costs for NSF advisory services, including some funds for site selection studies will approximate $2.6 million and estimates for the scientific programs on core analysis and other scientific work once drilling is being done have not been fully developed.

Through fiscal 1965, $36,150,000 has been allotted to the prime contractor for the project. Our budget request for fiscal 1966 was $11 million. However, because of the increase in known and estimated costs, we are faced with reprograming the project in view of the budgetary situation.

By deferring some items into fiscal 1967, particularly fabrication work, it appears possible to award the shipyard contract before the bids expire on October 10, 1965, and keep the project essentially on schedule if $7 million in addition to the $11 million requested can be made available in fiscal 1966. An appropriation of approximately $19 million would be required in 1967 and $4 million in 1968 to complete and break in the equipment. Because of the rise in costs the project is under review. A decision on the future course of action will be made within the next few weeks.

Following is a summary of appropriated funds allocated and expended for the Mohole project to date:

Phase I, including test drilling (allocated and expended)		**$1,810,000**
Phase II:		
Funds allocated:		
Fiscal year 1962	$1,594,490	
Fiscal year 1963	3,289,100	
Fiscal year 1964	7,977,338	
Fiscal year 1965	24,699,300	
Total		37,560,228
Funds committed (expenditures often lag 12 months or more behind commitments):		
Brown & Root contract allocations		36,150,000
NSF advisory services:		
National Academy of Sciences and National Research Council	390,900	
University of California	172,600	
University of Miami	2,700	
Ocean Science & Engineering Corp	134,028	
Woods Hole Oceanographic Institute	527,000	
Messinger Consultants Co	90,000	
M. Rosenblatt & Son	73,000	
North American Aviation	20,000	
Total		1,410,228
Total funds committed		37,560,228
Expenditures and commitments under Brown & Root contract (as of June 26, 1965):		
Funds allotted to contract		36,150,000
Expended	10,693,499	
Committed	2,996,629	
Total		13,690,128
Funds uncommitted by Brown & Root		22,459,872

F-14. In 1963 a special review of Project Mohole was conducted by a committee of the National Science Board under the chairmanship of Dr. E. R. Piore. The interim report of the Committee recommended certain reorganizational changes. (a) Specifically, what changes were recommended and were these recommendations carried out? (b) Was the final Piore report ever released? (c) Could a copy of the report be furnished the Committee for the record?

The recommendations of the National Science Board Committee under the chairmanship of Dr. E. R. Piore were made to the Board at various Board meetings. The Piore committee was established by the Board to advise it concerning the Mohole project, and to assist the Foundation in resolving the various difficulties which had arisen. As their work progressed, it became apparent that the Committee could serve more effectively through Dr. Piore's participation as a Board member in the decision process than by issuance of a formal report. Although several drafts of a proposed report were circulated among the Committee members to get their comments, none was transmitted to the Board.

Dr. Piore, acting on behalf of his committee assisted the Director of the Foundation in arriving at a solution which had the backing of the National Science Board. All of the most urgent points made by Dr. Piore's committee were taken into consideration in arriving at the plan for the project now being followed. These points were:

First, that the approach to very deep drilling be done on a conservative basis, incorporating stages of "intermediate" drilling both to get experimental experience bearing on engineering design and operating techniques, and to acquire samples useful for scientific purposes. In particular, the Committee felt that we

should not attempt to design and construct a *drilling system* having initially the full depth capability for penetrating the mantle. There was at the outset a spectrum of opinion in the Committee as to whether an "intermediate" *ship* was necessary. The Committee reached general agreement on the present plan which calls for a platform equipped initially for intermediate drilling but having the size and power supply necessary to permit, with some modification, the later Mohole effort.

Second, that the Mohole project be made part of a well-planned national effort in submarine geology. It was recommended that a program of shallow drilling in the ocean sediments be initiated as soon as funds could be made available, utilizing an existing drilling vessel modified for the purpose. The effort was begun a few months ago and some shallow drilling was accomplished under the auspices of the JOIDES group of oceanographic institutions referred to earlier. The work was done by the drilling ship *Caldrill* under charter.

Third, that the NSF organization to manage the project be strengthened. Mr. Gordon G. Lill joined the staff to assume full responsibility for the program as Mohole project director. He has built up a small staff augmented by the use of private consulting groups under contract.

Fourth, that a suitable organization be selected to assume responsibility for scientific operations. This suggestion has been studied as indicated in the response to question F–10. Two such groups have been considered, JOIDES and GURC, but no understanding has been reached.

A final written report from the Piore Committee was never prepared. The final oral presentation of the committee's recommendations was made to the National Sciences Board on September 13, 1963. The report was embodied in the resolutions approved on September 14, 1963, previously summarized. This presentation was the only final report that was made.

F–15. What are the objectives of the Foundation's ocean sediment coring program costing an estimated $5 million, and the international upper mantle project costing an estimated $31 million? (a) How do they relate to each other? (b) How do they relate to Project Mohole? (c) What is the difference between the mantle and the upper mantle? (d) In effect, doesn't Project Mohole include both of these programs since it is necessary to pass through both the ocean sediment and the upper mantle in order to reach the mantle of the earth?

The objectives of the international upper mantle project are to study the outer 1,000 kilometers (approximately 600 miles) of the earth in much greater detail and in many more places than has heretofore been accomplished. Attention is being focused on the upper part of the earth's mantle because of the influence which this zone exerts in the development of the earth's crust. It is here that many earthquakes originate, here is the source of volcanoes, and from here come the forces that build mountain ranges. The mantle itself is actually about 2,000 miles thick extending from the earth's core to the base of the comparatively thin crust. It is the upper part of the mantle that is receiving greatest attention. Most of the individual projects in the upper mantle effort are land-based; only a small num-

ber are being conducted at sea. The studies include seismic, gravity, and magnetic surveys, measurements of heat flow, and laboratory studies such as magnetic properties of rocks and the behavior of rocks and minerals under high pressure and high temperature.

The ocean sediment coring program, which is a direct outgrowth of Project Mohole, has little to do with the upper mantle project, except that both are aimed at learning more about the earth. The objectives of this program are to provide information about the history of the ocean basins, their age, their structure, and the evolution of marine life. It is hoped also that a long record of the earth's climatic history will be preserved in the sediments. Cores from shallower water on the Continental Shelf will show results of large-scale transgressions and regressions of the sea, and may provide the basic data that may eventually lead to exploitation of natural resources of the shelf, including new sources of underground water off our southeast coast.

In the spring of 1961, phase I of Project Mohole demonstrated the feasability of using a drilling vessel to obtain long sediment cores. Although this was accomplished as part of the Mohole project, it was soon recognized that the way had been opened for a program of deep sea investigations that was as interesting and perhaps as important as the Mohole itself. After some discussion it was recommended that, since a sediment coring program would not (in contrast to the Mohole project) necessitate a vast engineering development program, it should be undertaken separately from the Mohole, and operated directly by interested universities or oceanographic laboratories. Another reason for separating this program from the Mohole is that most of the coring in the sediment program can be accomplished from a much smaller and cheaper vessel than will be necessary to drill the Mohole. The first months of operation of the proposed Mohole platform will certainly yield a great number of sedimentary cores from the oceanic crust, but these will be in a comparatively few locations and will complement rather than compete with the sediment coring program, which will involve many more holes over wide areas of the ocean.

Project Mohole is related to the upper mantle project only in that it is listed as one of the U.S. contributions to that project. Project Mohole had already been started by the time the upper mantle project was suggested. Since the Mohole was already organized and is monetarily larger than all of the other upper mantle activities, the Foundation and Academy agreed not to try and reorganize it as part of the upper mantle project, but instead simply list it as an ongoing project that will be a major contribution to the upper mantle project.

F–16. What agency of Government, if any, has responsibility for the coordination of Federal research and development in the three fields of air pollution, soil pollution, and water pollution? Is such coordination a proper role for the National Science Foundation?

The Secretary, U.S. Department of Health, Education, and Welfare, has the responsibility to "conduct and promote the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention and control of air pollution" (Public Law 88–206, sec. 3 (a)(1)). These responsibilities have been delegated to the Division of Air Pollution, Public Health Service. To the extent that air pollution overlaps atmospheric sciences, further coordination of Fed-

eral research and development is accomplished through the Interdepartmental Committee for Atmospheric Sciences (a Committee of the Federal Council for Science and Technology), with the U.S. Department of Health, Education, and Welfare playing the major role.

Coordination of Federal research and development on water pollution is effected through the Committee on Water Resources Research (a Committee of the Federal Council for Science and Technology). Soil pollution is included to some extent with water pollution. In addition, soil pollution is of primary concern to the U.S. Department of Agriculture and the U.S. Department of Health, Education, and Welfare. These two departments coordinate their soil pollution research and development.

Since Federal research and development in the areas of air pollution, soil pollution, and water pollution are currently coordinated, there is no need at present for the Foundation to assume such a role.

G. SUPPORT OF SCIENCE INFORMATION SERVICES

G-1. Has the National Science Foundation made an effort to discharge the Presidential 1959 assignment of coordinating responsibility for scientific information activities of the Federal Government, or has it continued to follow the statutory authority given it by the National Science Foundation Act of 1950 and the National Education Act of September 2, 1958?

The three sources cited in the question, the National Science Foundation Act of 1950, the National Defense Education Act (title IX) of 1958, and the President's directive of January 22, 1959, to the National Science Foundation, are altogether in agreement on the fact that the National Science Foundation has responsibilities to the scientific community with respect to scientific information. These sources provide, in their succession, increasing detail and increasing emphasis on the importance of this responsibility and also provide additional policy guidelines.

The 1950 act authorized and directed the NSF "to foster the interchange of scientific information among scientists in the United States and foreign countries." The 1958 National Defense Education Act established within the Foundation a Science Information Service and directed the Foundation, through such Service to "provide, or arrange for the provision of, indexing, abstracting, translating, and other services leading to a more effective dissemination of scientific information, and undertake programs to develop new or improved methods, including mechanized systems, for making scientific information available." The Presidential directive of 1959, as expressed in President Eisenhower's letter of January 22, 1959, to Dr. Alan Waterman, requested the Foundation to implement the plan that was proposed by his Science Advisory Committee. The President indicated that implementation of the plan would necessitate that the Foundation "take the leadership for the accomplishment of effective coordination of the various scientific information activities within the Federal Government." In addition, the President wrote: "I urge that the fullest use be made of existing information services, both public and private, in supplementing rather than supplanting present efforts."

The Foundation has endeavored to fulfill the responsibilities as intended and as expressed in these legislative enactments and Presidential directive, and is indeed continuing to do so. The basic authority granted in the 1950 act establishing the Foundation was given significant impetus by the National Defense Education Act of 1958, and the programs pursued since that date have been designed to give effect to its provisions. The President's directive of 1959, has provided policy guidelines. Its broader import must be understood in the light of the recommendations of the Science Advisory Committee, which the 1959 directive sought to implement. This effort did not contradict the terms of the 1950 basic authorization to the Foundation nor the

more explicit authorization provided in the National Defense Education Act of 1958. The Foundation was unable fully to achieve the effective coordination of the various scientific information activities within the Federal Government.

The Foundation enjoyed a similar responsibility, although not described in these very terms, with respect to the broader research programs carried on by agencies of the Federal Government by virtue of the 1950 act which authorized and directed the Foundation (sec. 3a–6) "to evaluate scientific research programs undertaken by agencies of the Federal Government, and to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups." Reorganization Plan No. 2 of 1962, part I, section 3(a)(2) transferred from the Foundation to the Director of the Office of Science and Technology the function of evaluating scientific research programs undertaken by agencies of the Federal Government.

The need for effective coordination of science information activities within agencies of the Federal Government was the subject of continued discussion between the Foundation and the Office of Science and Technology, and also benefited by deliberation of the Committee on Scientific Information of the Federal Council for Science and Technology. In a letter dated February 13, 1964, addressed to the Director of the Office of Science and Technology, the Director of the National Science Foundation expressed the following views:

> One must recognize that each Federal agency has the responsibility of assuring that adequate scientific and technical information services are available to support its R. & D. activities. In addition, several executive departments and agencies have specialized roles in the nationwide dissemination of scientific and technical information; for example, the Department of Agriculture with information activities in support of agriculture; the Department of Health, Education, and Welfare in the field of health-related sciences; and the Department of Commerce in relation to information activities in support of industry and commerce.
>
> I agree with the recommendation of the Committee on Scientific Information that, under the intent of Reorganization Act No. 2, the Office of Science and Technology should provide leadership in effecting cooperation and coordination among Federal agencies with respect to their scientific and technical information activities. The National Science Foundation will, of course, assist the Office of Science and Technology in those areas where the Foundation has particular responsibilities.
>
> I consider one of the Foundation's primary responsibilities to be that of providing leadership in effecting cooperation and coordination among non-Federal scientific and technical information services and organizations toward the end of developing adequate systems for the collection, organization, and dissemination of information. Also, the Foundation has a major responsibility in developing adequate relationships between Federal and non-Federal scientific activities. All of the Foundation's scientific information activities, including the above, would, of course, be under the coordinating purview of the Office of Science and Technology just as are scientific and technical activities in all other executive branch agencies.

In expressing his concurrence with these views, the Director of the Office of Science and Technology replied on February 28, 1964:

> I fully concur with your views and support the concept that the National Science Foundation shall provide leadership in effecting cooperation and coordination among non-Federal scientific and technical information services and organizations, and in developing adequate relationships between Federal and non-Federal scientific activities. The Office of Science and Technology, with the assistance of the Federal Council for Science and Technology shall provide overall leadership of all Federal scientific and technical activities, including the

above, in accordance with Reorganization Act No. 2 which mentions the following responsibilities of the Office of Science and Technology: (1) major policies, plans, and programs of the various agencies; (2) assessment of selected developments and programs; (3) review, integration, and coordination of major Federal activities in science and technology, giving due consideration to the effects of such activities on non-Federal resources and institutions; and (4) assuring that good and close relations exist with the Nation's scientific and engineering communities.

The Foundation, its Office of Science Information Service, and the Office of Science and Technology have had the experience of 1½ years of activities with the relationship as agreed upon in this interchange of letters. We have witnessed significant improvement in our functions by virtue of the concentration of effort that is now permitted. We have also seen some promising undertakings which have been made possible through cooperation with the Office of Science and Technology within the spirit of this new and still developing relationship.

In short, with the exception of the requirement contained in the President's directive of 1959 for coordination of science information activities within agencies of the Federal Government, the Foundation is following the three cited sources of authority and direction. The foregoing explanation has attempted to point out that these authorizations and directives are not contradictory but rather supplement and reinforce each other. The responsibility for coordination within the Federal Government is exercised by the Office of Science and Technology: coordination with the private or nongovernmental community is recognized as a Foundation responsibility.

(See also G-2.)

G-2. What steps are being taken by the Foundation to improve the techniques for the dissemination of scientific information and the understanding of the actual dynamics of the communication process?

For more than a decade, the Foundation has supported research on the communication process in science and on techniques for the dissemination of scientific information. Since early in 1964, more emphasis has been given to practical applications of research results. The following paragraphs summarize the major accomplishments and current efforts.

UNDERSTANDING OF THE COMMUNICATION PROCESS

From the studies supported by the National Science Foundation thus far, a relatively complete description of both the formal and informal processes of information exchange in one discipline, psychology, has been developed; this description has led to certain hypotheses about innovations in journals and meetings which we hope will lead to improvements in communication and which are now being tried experimentally. Useful data on communication practices and problems have also been, or are being, gathered in other disciplines: Chemists' communication activities and information sources; reading habits of chemists and physicists; search requests of physicists (analysis of them had led to improved indexing of physics journals); information exchange in the field of communications research; information sources used by engineers; communication channels used by biologists in a few selected laboratories; and the communication behavior of a large sample of industrial researchers. We hope to have within

2 years or so a more complete understanding of the communication process in several disciplines, in addition to psychology, which will help to determine how information services might best be improved.

Several studies of the interrelationships displayed by citations in scientific papers are serving to identify the "core" literature and the communication networks of the various scientific disciplines. Attention is also being given to the stimulation of new work in which other methods of studying the use of information and its impact will be employed. Thus far, studies have relied primarily on what users say they do; we hope to explore more fully the feasibility of studying communication behavior directly and its relationship to effectiveness in the performance of scientific tasks. A beginning has been made with a study of the role of information in a number of parallel research and development projects.

IMPROVED TECHNIQUES

The Foundation supports research on new approaches to the classification and indexing of information, including the feasibility of automatic classification and indexing; the results of much of this research have yet to be applied and evaluated. Several test environments have been established, within which indexing and searching techniques are being tested and evaluated. A number of basic theoretical and methodological studies are relevant to the design and evaluation of information-handling techniques and systems; particular attention is being given to methods for evaluating performance, since it is essential to be able to determine objectively whether a new technique is, in fact, an improvement over an older technique. Two new kinds of indexes, citation indexes and permuted word-in-context indexes, have been introduced with NSF support; we are now planning a program of studies to assess the utility of these and other published indexes by gathering and analyzing precise data on the search methods used with them and the results obtained. Research on automatic language processing is directed toward the possibility of automatic analysis of document content and mechanical translation. The results thus far, such as computer programs for syntactic analysis of sentences, have been used primarily in further research efforts. More work is needed before practicable application of such techniques in information services will be possible.

On behalf of the interested Federal agencies (NSF, DOD, and HEW), the National Science Foundation is monitoring a federally supported effort to adapt computer techniques to the control of information on several million chemical compounds; this effort is the first step toward a national computerized information system to serve chemists. The National Science Foundation is supporting several trials of the application of computer-controlled printing technology to the publication of scientific journals and abstracting and indexing services; and, also, a number of experiments with computer applications to library operations with a view to improving science library service in the United States.

(See also G-1; G-9.)

G-3. Does the Science Information Council's function conflict with that of the Committee on Scientific and Technical Information?

No. The Science Information Council is advisory to the National Science Foundation and its Office of Science Information Service in providing guidance on NSF's science information programs and responsibilities. The Committee on Scientific and Technical Information is a committee of the Federal Council for Science and Technology, composed of science information representatives of the several Government agencies engaged in such activities for the purpose of coordinating and improving their activities.

Although the same or similar subjects and problems will concern both groups at times, the composition, mission, relationships, and responsibilities of the two groups are different and, thus, there is no conflict between them.

G-4. What effect does the formation of the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, have on the responsibility of NSF for scientific information dissemination?

The Foundation welcomes an efficient and effective clearinghouse and continues to cooperate with the clearinghouse. The growing importance of the technical report literature generated as a result of Federal agencies' scientific research and technical development activities has created a need for access to this literature not merely on the part of Federal agencies but also by scientific and technical personnel in industry, in universities; and elsewhere. This problem was a major concern to the Office of Science Information Service until the advent of the clearinghouse which provided the basis for a coherent service responsive both to governmental and nongovernmental requirements. The Foundation also utilizes the facilities, services, and the specialized competence of the clearinghouse staff to aid in several of its own operations, as in the case of the Foundation's responsibility for coordinating the Government agencies' requirements for translations of foreign literature with the aid of excess foreign currencies, or for special bibliographic services related to reports resulting from the Foundation support of research and development in science information.

G-5. Several witnesses have alluded to the lag in statistics for policy planning for which the National Science Foundation has a focal responsibility. For example, it is noted that on July 9, 1965, the latest information available through "Federal Funds for Research, Development, and Other Scientific Activities" are estimates for fiscal year 1964 that were submitted to the Congress in January 1963.

(a) What steps are being taken to improve the timeliness of information?

(b) Is additional automatic data processing equipment required and are plans for its procurement being formulated?

I would first point out that in many instances what is interpreted as a lag in the availability of statistics results from a lack of knowledge as to what is available and from what sources and in what form. It is true that the latest data actually published in "Federal Funds" as of July 9, 1965, were those contained in volume XII. Volume XIII was published less than 3 weeks later, on July 26, 1965. Furthermore, data subsequently included in volume XIII, based on the budget submitted to the Congress in January 1964, had been published as a congressional document in September 1964. The preparation for publication of this information, relating to the geographic distribution of Federal R. & D.

funds, was a factor in the delay in publication of "Federal Funds," volume XIII. The statistical tables from volume XIII, however, were made available to interested parties during the latter part of 1964 and early 1965.

Recently, an editorial in the journal Industrial Research characterized as "helpful but outdated" an NSF report entitled "Industrial R. & D. Funds in Relation to Other Economic Variables," issued in 1964, and cited this as an example of the lack of currency of NSF R. & D. data because the report used 1958 data collected in the 1958 Censuses of Business, Manufacturers, and Mineral Industries. Unfortunately, the writer of this editorial failed to mention the statements, specifically included in the foreword and the introduction of the 1964 NSF report, that the data on other economic variables—items completely beyond the scope of NSF surveys—had become available only a few months before the Foundation's analysis was published, and that the latest year for which the Bureau of the Census has compiled these company figures was 1958. I do not wish to be thought overly defensive in this connection, but it is not unreasonable to hope that those who are interested in these matters will take into account some of the limitations under which we must at times operate.

Having noted, therefore, that we are on occasion criticized somewhat too severely, let me now say that I recognize fully that we must do more to assure prompt and timely publication of useful information.

The Foundation has taken a number of steps to provide published statistics on a more current basis, and without sacrificing accuracy, completeness, or competent analysis. It is anticipated, for example, that "Federal Funds for Research, Development, and Other Scientific Activities," volume XIV, based on the President's budget for fiscal year 1966, will be published in September or October of this year, approximately 10 months ahead of the schedule followed for volume XIII, which was published July 26, 1965. Significant improvement has also been made in publishing more current annual surveys of industrial R. & D. performance. Thus, the data from the 1964 industrial survey, for which the questionnaire was mailed to the companies in March of this year, will be published around November or December of 1965. This schedule represents an advance of 5 or 6 months over the publication time of the earlier industrial survey reports.

Improved and expanded data processing facilities will also contribute to our ability to produce and publish more timely information. A study has indicated that our present data processing equipment has become inadequate for our needs, and we have already initiated action to acquire a larger computer. The selection and procurement process is underway; delivery is anticipated in January 1966. Concurrently, our data processing staff is being enlarged to provide the necessary systems analysis and computer programing capabilities needed to assure optimum utilization of this computer for statistical analyses. The new capability being developed will still need to be augmented, as heretofore, by using outside contractors for certain tasks which (because they involve large operations or particularly urgent time factors) cannot be handled by an internal system of the size and type considered most appropriate for NSF.

(See also B-3.)

G-6. Concerning NSF collection and analysis of information about research and development—(a) What information would be desirable from Federal departments and agencies to adequately portray the regional distribution of Federal and private research and development activities? (b) How much of this information is now regularly available? (c) What has the Foundation done to advise and guide departments and agencies concerning collection of such data?

a. What information would be desirable?

It would be desirable, if the issues being posed about the geographic distribution of Federal funds are to be considered wisely, for each Federal department and agency to provide information about its obligations and actual expenditures for research and development on a State basis and on a standard metropolitan area basis. The information arrayed by these geographic units should show obligations and actual expenditures for research and for development separately; by basic and applied research separately; by fields of science for basic research; by intramural and extramural performers; by type of extramural performer—colleges and universities proper, Federal contract research centers, nonprofit research organizations, private foundations, and profit organizations; by type of academic institution classified on the basis of highest degree awarded and public or private; by location of subcontract performers, if any, down to the third tier, as well as location of prime contract or grant.

To what extent it would be feasible for Federal departments and agencies to meet these specifications for information, useful for delineating regional and other patterns of Federal funding and performance of research and development, is a question which will require separate exploration. We know from discussions of this general matter that the degree of detail here specified as being "desirable" may be obtainable only at excessive cost in terms of resources which could better be used for other purposes.

It should be noted that we are assuming in what follows that the reference in this question to "private research and development activities" refers to Federal grants to and contracts with private enterprises or organizations (both profit and noprofit), since information about research and development expenditures by private enterprises and organizations themselves cannot be provided by Federal departments and agencies.

b. How much of this information is now regularly available?

From time to time individual agencies have collected geographic data on research and development and other scientific activties on a need-to-know basis. Generally, such data are designed to cover a specific area of interest. It is anticipated that specialized requests for geographical data from individual agencies will continue to be made and that the appropriate data will be provided. For example, early this year Senator Ribicoff asked five agencies (DOD, NASA, AEC, HEW, and NSF) to provide data on obligations for research, training, and facilities by educational institutions for fiscal years 1963, 1964, and 1965. Each of the agencies submitted the requested data.

In addition, the NSF, as an auxiliary part of its "Federal Funds for Research, Development, and Other Scientific Activities" series, collected data pertaining to the geographic distribution of Federal

research and development and R. & D. plant obligations for fiscal years 1961–64. These geographic data have been published in full as a congressional document.[1] This survey represented the first full-scale effort to compile geographic Federal R. & D. data using a consistent set of definitions. It covered the eight major R. & D. supporting agencies, which account for over 98 percent of total Federal R. & D. obligations.

To accommodate some of the respondents, it was necessary to obtain the data for research and development as a combined amount. Furthermore, data were requested for prime contracts and grants only. Prior to the survey, most respondents indicated that they did not think it feasible to develop geographic data on subcontracting. The data were identified by the major categories of participating performing organizations mentioned above.[2] The Foundation is planning to collect data on the geographical distribution of Federal R. & D. obligations again next year, in its annual "Federal Funds" series.

Thus the information regularly available is substantially less detailed than that which is *a* above we have noted would be "desirable." We have been endeavoring to find ways of coping with this problem. There is no simple solution, for the statistical difficulties involved (which are in themselves great) are compounded by numerous highly intractable definitional problems.

Even so, by combining reports from performing organizations and from funding agencies (and, to a limited extent, from individuals—through the National Register of Scientific and Technical Personnel) we are gradually building up a significant body of information concerning geographical distribution of research and development funds.

c. What has the Foundation done to advise and guide departments and agencies concerning collection of such data?

As noted above, the Foundation in 1964 collected data on geographic distribution of Federal R. & D. obligations as an auxiliary part of its "Federal Funds" survey. The Foundation developed the geographic questionnaire only after meetings and agreements with the agencies. In turn, the Foundation assisted the respondents with the interpretation and application of the survey questionnaire. Where inconsistencies in reporting were evident, questions were raised as to what should be reported. The ultimate decision, however, on how the geographic distribution should be reported, was of necessity left to the discretion of the agencies, since (as the question properly notes) NSF can "advise and guide" but cannot "direct" other agencies with respect to such matters.

G–7. Since the Foundation does not require technical reports at the conclusion of a research grant, does this prevent the Science Information Service from carrying out its responsibility of leading to a more effective dissemination of scientific information?

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[1] The complete data derived from this survey were published in September 1964 by the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, "Obligations for Research and Development, and R. & D. Plant, by Geographic Divisions and States, by Selected Federal Agencies, Fiscal Years 1961–64." This report contains more than 250 statistical tables that identify the geographical distribution of Federal research, development, and R. & D. plant obligations by the major participating performing organizations, i.e., intramural (Federal Government), educational institutions, profit organizations, other nonprofit organizations, and other performers.

[2] This means, for example, that an agency's awards to all educational institutions in a State were reported, but not on an institution-by-institution basis.

The National Science Foundation requirements for technical reports are stated as follows in booklet NSF 63–27 entitled "Grants for Scientific Research" (p. 23):

> A short informal annual report and a more comprehensive report at the termination of the grant are required. When the grant is for a period of 1 year or less, only a final report is required. It is requested that the final report contain a chronological bibliography of all publications resulting from the work aided by the grant. Four reprints of each publication should be provided as soon as such reprints become available. If adequate to serve that purpose, they may be submited in lieu of annual reports. The Foundation would appreciate being informed of any results of unusual interest whenever they occur.

The Foundation's willingness to accept publications, if adequate to serve the purpose, in lieu of reports, results from the Foundation's belief that publication of research results in the open literature, usually in scientific journals, is the best way to disseminate such results. The journals, in general, reach a wider community than do technical reports; and, in addition, the journals are covered by abstracting and indexing services, whereas technical reports often are not covered by these bibliographic services.

The encouragement of publication of research results, in lieu of technical reports issued for limited distribution, does not prevent the Science Information Service from carrying out its responsibility of leading to a more effective dissemination of scientific information, for journal publication leads to more effective dissemination than the issuance of technical reports.

G–8. How does the Foundation monitor agency responses to assure conformity to definition and to quality standards for statistics?

For its annual surveys for the "Federal Funds for Research, Development, and Other Scientific Activities" series, the Foundation provides the Federal agencies with instructions, concepts, and definitions, and assists them with the interpretation and application of the survey questionnaire. New questions are introduced in the surveys only after meetings and agreement with the agencies. Meetings are held with the major agencies prior to initiation of each annual survey. Liaison is continued with the major agencies throughout the year. In addition, the major agencies are provided the data they reported in the preceding report and these "shuttle" data are used to encourage comparability of reporting from year to year.

The Foundation evaluates the responses when they are received and raises questions when inconsistencies in reporting are evident. The ultimate decision, however, on how activities will be classified and the amounts to be reported is left to the discretion of the agencies.

When, for conceptual reasons, an agency revises the classification of its R. & D. operations and the resulting allocation of funds, it is asked to revise its previous reports in order to establish consistency and comparability with the current report.

It should be recognized that no statistical inquiry is free from problems for the respondents arising from the application of definitions. Classification is particularly troublesome for the respondents because scientific activities are abstract and far from immutable, and they resist easy summarization into dollar and manpower terms. An element of subjective "best judgment" often enters when an agency classifies its operating programs and identifies funds for basic research, applied research, or development. Admittedly, there are often no

clear-cut demarcations between these work categories. The same element of subjective best judgment also often exists in classifying large interdisciplinary undertakings by primary fields of science. Since only the most important criteria can be encompassed by a definition—without an encyclopedic enumeration of all relevant criteria—assurance that the agencies conform to the definitions can be attained only in a relative sense.

G-9. Are there enough funds available for carrying out experiments to apply new knowledge, techniques, and equipment for more efficient information retrieval systems?

The funds available in the immediate past years have been reasonably sufficient to support experimental applications of new knowledge, techniques, and equipment to information systems. This has necessitated, however, careful screening and support of a limited number of such activities. We presently foresee an increasing pressure for exploitation and application of newly developed capabilities. This pressure will be amplified if the present thrust toward development of national information systems is followed through. A 2-year experimental effort to determine the feasibility of a national chemical information system required cooperation by three agencies to provide the $4.2 million entailed in this effort. If anticipated efforts by organizations serving the communities of physicists, engineers, and other disciplines materialize, the present funding level will be far from sufficient to satisfy the implied requirements.

(See also G-2.)

G-10. The fiscal year 1966 budget request contains $9.5 million for university computing facilities, including replacement of computers provided in the late 1950's. (a) Does the National Science Foundation let grants for renting computers as well as buying them? (b) Would it be more economical for the Foundation to have rented the computers which it is now replacing?

(*a*) Yes.

(*b*) In our opinion, no. In judging the merits of a proposal for assistance to an institution planning to rent or purchase a computer, the Foundation gives particular consideration to the soundness of the institution's financial plans and to its justification for the choice between renting or purchasing its equipment. We have found no reason to impose a uniform policy favoring either of these options, since in each individual case a number of factors must be considered. Among such factors are the institution's financial resources including limitations such as those that might be imposed by the State legislature, its administrative structure, any special circumstances involved with the computer manufacturer, as well as the expansion of the use of the computer in the institution's research and educational activity. In many cases, also, the institution's judgment as to the probable useful life of the equipment differs from that of the Government auditors who often insist on depreciation over much longer periods. Typically, purchase prices set by computer manufacturers are between 45 and 50 times the equivalent monthly rental; understandably the imposition of a substantially longer base for depreciation can affect the institution's choice. In all cases, the Foundation's contribution has amounted to substantially less than the full cost of buying or renting the equipment.

The wording of the question suggests that the Foundation itself rents or purchases computing equipment for university use, questioning whether, under such circumstances, it would have been more economical to have rented this equipment in all cases. As indicated above, this has not been the manner in which this program has operated. We estimate (NAS–NRC report "Digital Computer Needs in Universities and Colleges," in draft) that there is today an investment of $9 million in equivalent monthly rental at colleges and universities, of which about 50 percent is being supplied through manufacturers' discounts. By 1969 this investment will have increased to more than $18 million of which less than 35 percent will be offset by manufacturers' discounts. This generous discount policy to educational institutions on the part of computer manufacturers in itself more than offsets the economies which could be derived through consolidated purchase or rental options available to this agency.

H. Scientific Manpower Problems

H-1. You testified that, in general, there is not enough financial support to go around for all the good men available. (a) What level of support is needed? (b) How much more support is needed overall than at present? (c) What are the basic problems in meeting our national goals on manpower?

During the past several years the Foundation has been able to make grants in support of only slightly more than half of the research proposals on which it acts, despite the fact that 80 to 90 percent of the proposals are adjudged to have sufficient merit to warrant some support were the funds available. On an annual-rate basis the average amount granted for those proposals which are supported is of the order of two-thirds of the amount requested. On a weighted basis the average proposal requests a duration of about 2.5 years whereas the average grant given is for about 1.6 years. Reductions in annual rate are accomplished by reducing the amount of equipment and the number of personnel for which support is provided. It may be roughly estimated that if all proposals which are now supported by the Foundation received support at an optimum level rather than a stringent one as at present, an increase in available funds by about 20 percent would be required, assuming no increase in duration. If, in addition, those worthwhile proposals are to be supported which are now being declined, but which would receive support if funds were available, an additional increase by about 50 percent would be required. In summary, an overall increase by a factor of about 80 percent would be required to adequately take care of all the worthy projects proposed to the Foundation. The basic research project support budget for fiscal year 1966 is estimated at $155 million. The amount required to provide reasonable support for all good proposals would be closer to $280 million. We are unable to determine on a meaningful basis the number of able scientists and engineers who—in part because they know that competition for available funds is so keen—do not submit proposals. We know of enough such cases, however, that it seems quite reasonable to assume that they constitute a considerable number—perhaps as much as half of those who do submit. However, it seems safe to assume that the larger group and somewhat more expensive efforts are well represented in the requests received, so that the additional proposals we might receive under more affluent circumstances would not, on the average, be for as large amounts as is the case at present.

A basic problem in meeting the Nation's manpower goals lies in defining the manpower needs. No one has solved this problem fully. It is difficult, in a system as complex and dynamic as is the U.S. economy, to determine the supply of and demand for individuals of given types of skill or preparation on a current basis. It is not possible to determine what the demand (and, to a lesser extent, supply)

will be a number of years hence. To do the latter would require a fairly detailed knowledge of scientific discovery and technological developments as yet unknown, the State and nature of the national and world economy and social development, and the employment aspirations of individuals.

Further, while it is perfectly possible to educate and train individuals to perform specific duties, that way leads quickly to manpower obsolescence. In the Foundation's view the most rational approach to the problem of scientific and technological manpower is to provide educational opportunities for a comparatively large pool of individuals, and encourage an educational approach that leads to breadth of knowledge rather than narrow skills. This approach leads to highly flexible manpower supply, the only meaningful kind for an unpredictable future. We must not lose sight of the implications of the fact that, of our leading nuclear physicists, only a scant few were originally so trained: the same is true in oceanography, biophysics, computers, molecular genetics and most of the other fields of science now most active.

H-2. Are further studies needed to make long-range plans of Federal agencies more reliable in forecasting future requirements for scientific and technical manpower? If so, of what nature?

Yes, further studies of this type are clearly needed, but it should be recognized that the problem on which they will focus bristles with difficulties, whether it is that of forecasting the requirements for scientific and technical manpower of the Federal Government or of the Nation as a whole. (I mention these alternatives because it is not clear whether the question has in mind the first, second, or both.)

Better—in the sense of more accurate and reliable—forecasts of manpower requirements than are now available will, I believe, depend upon studies of a quite fundamental nature which (*a*) improve the information available on the quantitative and qualitative characteristics of existing stocks of scientific and technical manpower and of existing employment patterns within the public and private sectors; (*b*) illuminate understanding of the factors affecting demand and supply; (*c*) identify the sources of error implicit in techniques used up to now and revealed by the shortcomings of their results; (*d*) provide better clues to impending and more remote changes in the direction, content, and purposes of public policies; (*e*) investigate in detail the experiences and behavior of governmental employers in the labor market; (*f*) center on problems of utilization, mobility, substitutability, obsolescence, and retraining of scientific and technical manpower; (*g*) determine the feasibility of developing techniques for forecasting technological innovations and changes; and (*h*) seek to determine the consequences for national policies of alternative assumptions with respect to different requirement levels, conceived both as expressions of social "needs" and of effective demand.

Still other types of studies would also contribute to more reliable forecasts. This has been made clear as a result of the attention paid to this subject by the NSF, the Department of Labor, the President's Committee on Manpower, and others. Those studies which I have mentioned in shorthand fashion should not, therefore, be viewed as constituting an exhaustive list. It is perhaps worth adding that my impression is that among experts in this field there is currently no

high optimism that striking advances in forecasting techniques and results should be expected to be made in the immediate future.

H-3. What does the Foundation consider its responsibility to be in the area of retraining? Does it feel this element of manpower utilization and refreshment as important as the development of new manpower?

Because of current needs for qualified scientists and teachers of science, the Foundation feels that its retraining activities are as important as the development of new manpower. The retraining activities supported by the National Science Foundation serve all segments of the scientific community. These activities provide opportunities for the retraining of out-of-date teachers of science and the updating of scientists engaged in research, principally (but by no means exclusively) in universities.

Retraining of scientists and engineers employed in for-profit (industrial) organizations is important, but this problem is one which the Foundation has approached cautiously, insofar as specific programs directed toward this group is concerned. The retraining of teachers is directly related to the Foundation's responsibility; the relationship of the industrial scientist or engineer to our assigned functions is less clear. The Foundation's limited activity in assisting non-university scientists is directed principally at the encouragement of effective "self-help" projects for individuals. The Foundation is, of course, concerned that appropriate opportunities for "refresher" training at universities be available to all those who can, by virtue of such training, make more effective contributions to science and technology. Thus, although the Foundation's major effort in the area of retraining has been centered on teachers and researchers closely associated with the educational establishment, several of our programs explicitly make provision for participation by Government and industrial scientists.

Perhaps best known among its varied "retraining" activities is the Foundation's large program of institutes and conferences offering group-training for teachers of science, mathematics, or engineering at the various educational levels. In fiscal year 1965 alone the estimated number of teachers who received support for institute participation totaled 41,910 (4,082 college teachers, 34,397 secondary school teachers, 3,431 elementary school personnel). The number of teachers in our schools and colleges who are teaching science, mathematics, or engineering is enormous. Not only is retraining required for those who were inadequately prepared initially, but updating of scientific knowledge for all teachers in the sciences becomes necessary as scientific knowledge expands and advances. To date, NSF-supported academic year institutes, summer institutes, inservice institutes, and conferences have made significant progress in helping teachers improve the quality of their science instruction. There is, of course, much more that remains to be done in this area.

In the interest of helping to alleviate the national shortage of science and mathematics teachers—which increases as student enrollments expand—the National Science Foundation has been exploring new sources of potential teachers and experimenting with retraining programs specially designed for the needs of this group. These experimental efforts which have been supported on a limited scale since 1957,

are especially the responsibility of NSF since they provide novel approaches to the problems of manpower for science education.

Retraining and initial training are not competitive, but complementary activities. Their interrelationship is so great that it is difficult to assign relative importance. For a short range need, support of refresher training for those who already had some experience in the sciences and teaching appears to be logical. For a long range requirement, it might be preferable to provide first-rate instruction to college students whose primary interests were in science and mathematics teaching and to encourage them to make a long-term, successful career of teaching. It is true that in time these new teachers will become outdated, but the point is that with good initial training, the only supplementary training required will be that of updating, without the additional burden of removing original inadequacies.

The Foundation has always, in its science education activities, stressed the importance of quality. This has meant (and still means) that NSF efforts have been directed toward assuring the maintenance and strengthening of strong educational programs of high quality wherever science is taught—no matter who the students may be. We have supported extensive efforts to find better programs of study in several fields (engineering, for example), and to the extent that these efforts are successful they will be as applicable to those preparing for (or now working in) industrial jobs as for those employed in other sectors of the economy.

The matter of the relative importance of "initial" and "refresher" training cannot be answered simply, because there are so many factors to be considered under a given set of circumstances. As our program activities show, we currently assign high priority both to initial training and to retraining programs.

H-4. What studies, if any, is NSF sponsoring to provide more information on the nature and rate of obsolescence for scientific and engineering personnel, and about effective countermeasures? Are we ignoring or wasting the technical manpower resource of older scientists whose early academic training has been superseded by new methods?

The problems involved in defining and assessing obsolescence in scientific and engineering personnel are manifold. Though we cannot predict the extent and timing of obsolescence in an individual as one might in a machine, we must assume that obsolescence, however the term is defined, will take place. An exploratory study has been completed under our auspices, the object of which was to determine the potential usefulness of evaluating representative formal and informal types of continuing education in offsetting the obsolescence of technical skills of scientists and engineers. The Foundation is now in the process of conducting discussions with prospective contractors, to further refine the issues and design, preparatory to launching a full-fledged study. In addition, the study of the impact of R. & D. instrumentation on scientific and technical manpower recently undertaken by the Battelle Memorial Institute with the support of the Foundation will concern itself in part with the extent to which increasing dependence on advance instrumentation systems for the performance of R. & D. increases the obsolescence of the skills and technical competence of professionally trained scientists, engineers, and technicians.

Specific countermeasures have been developed and, in our opinion, pursued with some success in areas such as:

(*a*) Studies of both undergraduate and graduate curriculums by national groups, such as the Commission on College Physics and the Committee on the Undergraduate Program in Mathematics, in specific areas of science and engineering with the subsequent publishing of recommendations or "guidelines." These guidelines are in important countermeasure against obsolescence in that they make specific recommendations for curriculum construction to be used by colleges and universities in remodeling their old programs for training scientific and technical personnel or establishing new programs. Two characteristics of the work of these groups are worthy of note here: the recommendations are based on (1) a philosophy which will result in a training program general enough to insure maximum adaptability in the individual as well as specific enough to insure competence "on the job" initially, and (2) a thorough consideration of the future of the particular field to insure optimum utilization of up-to-date subject matter in the form of revised courses and innovations in learning experiences.

(*b*) Studies of the content of specific science courses and the development of model courses which (1) in addition to being representative of the most modern subject matter content also offer methods of presentation of the material which are responsive to present day theories of learning and knowledge of human behavior and (2) are designed to foster in the student habits of independence of thought and an ability to learn from one's own inquiry. These factors are, in our opinion, of upmost importance in combating intellectual obsolescence in any field.

(*c*) Support of programs designed to retrain and update personnel in all segments of the scientific community through individual or group study lasting as long as an academic year or more or an advanced level seminar lasting for only a few days. These programs retrain out-of-date teachers of science at all levels and update scientists engaged in research in universities as well as scientists in industry and government.

The NSF is not ignoring the older scientist whose early training has been superseded by new knowledge and methods. A recent study of the records of some 18,500 individuals applying to NSF-supported retraining programs and the approximately 6,500 individuals who actually participated shows a clear trend toward selection of the older scientist. Using age data from the National Register of Scientific and Technical Personnel, the typical scientist is about 38 years of age. The typical scientist participant in NSF-supported retraining programs (institutes, conferences, and research participation programs) during the last 2 years is about 40 years of age. In addition, a comparison of the age distribution of applicants to these programs and the age distribution of participants shows a clear trend toward the selection of the older individuals from among those applying. In each 5-year age category above age 40 (except age 66 and over) the percent of total participants is greater than the percent of total applicants in that same category.

H-5. What is known about the size and makeup of that part of the population which has the basic capacity to become scientists or engineers? Does this set the ceiling on their production? Could more graduate students be supported without compromising quality, or has this limit already been exceeded?

If one uses as a criterion for "basic capacity" an IQ (Army standard scale) score of 110 or better, in a distribution of the general population, approximately 30 percent of each age cohort possesses the requisite capacity. Among 1965–66 high school graduates, this will be approximately 1,266,500 boys and girls, 622,000 being boys. However, capacity is not the only factor. The limit upon producing scientists and engineers is also greatly influenced by difficulties at the high school and college level resulting from inadequate preparation, by motivation (a problem associated with sex, parental occupation and education, ethnic and religious background, and other sociocultural factors), by income (the problem of support for students), and by other pressing responsibilities induced by society (such as marriage responsibilities and military duty). General capacity may be subdivided into a number of more elementary aptitudes. A major national study designated as Project Talent developed, on a judgmental basis, four measures (general academic aptitude, quantitative aptitude, technical aptitude, and scientific aptitude), and identified 17.4 percent of high school graduates as having "exceptional scientific aptitudes" using as a measure those scoring in the 90th percentile on at least one of these tests.

Using this more limiting criterion, there will be as many as 441,000 high school graduates in 1965–66 having "exceptional scientific aptitudes." Project Talent test results showed that boys scored better in these aptitudes than girls. The respective estimates for the 1965-66 graduates are 362,000 boys and 79,000 girls who will possess exceptional scientific aptitudes.

Not all of these will enter college, however. It is variously estimated that two-thirds to three-quarters of boys from the top third of their high school graduating class and one-half to two-thirds of the girls from the top third of the class enter college the following fall. Dropout from college further depletes the number, generally estimated at 40 percent dropout of all entrants. Studies suggest that about one-third drop out because of poor academic performance and one-third because of finances.

Among those receiving the baccalaureate, approximately one-third have academic records of B or better (excluding those with an average of B— or less), and about three-fifths have records of B— or better. While some college graduates with poorer records attend graduate school and receive master's and even doctor's degrees, let us consider those with undergraduate records of B— or better as qualified.

Upon this basis, and using the results of several surveys, the following estimates were made of the percent of capable baccalaureate recipients who are not enrolled for graduate study the following fall and

what this means in terms of numbers of 1965–66 bachelor's degree recipients who will probably not enroll for graduate study in 1966–67.

	Percent of capable baccalaureates not enrolled for graduate study following fall	Estimated number of 1965–66 class who will not enroll 1966–67
Physical sciences	38	11,500
Engineering	29	4,800
Life sciences	46	9,200
Psychology	32	2,300
Social sciences	66	12,000

The high percentage for the social sciences is due to the larger proportion of females who receive baccalaureate degrees in these fields. As time passes more graduates undoubtedly will enter advanced training. It is clear that additional capable baccalaureates could be supported in graduate study.

In summary, approximately 30 percent of each age group is capable of being trained in the sciences. The limitation on developing scientists is not only native capacity but high school and college graduation, which, in turn, rests upon prior preparation, motivation, income, and the presence of other demanding responsibilities.

There still are capable baccalaureates in science fields, perhaps approximately one-third of the capable graduates, who are not immediately entering graduate study. The "interface" between high school and college and the various "weeding out points" between college entrance and college graduation, however, are much more important sources of loss of potential scientific talent than between college graduation and entrance into graduate study.

If the United States is successful in achieving its goal of equal educational opportunity for all, we will have many more well-qualified students available as potential candidates for advanced degrees in science and engineering—as well as in all other fields.

II–6. What is the explanation for the NSF report in which a shortage of scientists and engineers was projected under the next 10 years, in contrast to the Killian report released about the same time that cited no across-the-board shortage?

The NSF report in question is "Scientists, Engineers, and technicians in the 1960's (NSF 63–34) which was prepared by the U.S. Department of Labor in 1962 with financial support by the Foundation. The report appraised the growth of scientific and technical occupations and concluded, under the assumption of growth rates continuing through the 1960's at the same approximate rates as during the late 1950's, that the college output of new bachelor degree scientists and engineers would be insufficient to meet needs by 1970. The report pointed out that such trends might change, however, and that such projections themselves might be influential in changing demand-supply relationships.

The report of the Committee on Utilization of Science and Engineering Manpower entitled "Toward Better Utilization of Scientific and Engineering Talent—A program for Action" (better known as the Killian report) was issued in 1964, at a time when readjustments in the defense and space programs had resulted in contract cancellations and even release of some engineers by industry. The report concluded that:

> At present, there are both unfilled positions and unemployed scientists and engineers. Conditions vary by region and specialty. There are unmistakable shortages of manpower in the advance technologies of new engineering systems, of scientists and engineers with technical and administrative skills required for the effective management of large scientific and technological undertakings, of teachers of science and engineering, and all persons with doctorates in mathematics.
>
> Also at the present time, there are identifiable surpluses resulting, for example, from industries changing from older to new technologies * * *. Currently, changes in the programs of the Department of Defense are resulting in cutbacks in certain types of employment. A number of engineers face problems of adapting themselves to more advanced technologies as the older skills become obsolete. Thus, the employment situation remains mixed.

Any comparison of the findings of these two reports should note that one represents a projection of trends of the late 1950's to 1970 under clearly stated assumptions. The other report speaks to the situation found in 1964, a year of Government contract readjustments. The NSF report made no appraisal of the situation in 1964, and it is possible that if it had done so, its conclusions for that year might not have been far different from those of the Killian report. This is to say that a situation projected for 1970 will not necessarily be reflected to the same degree in each prior year.

As hazardous as projections can be in any area as uncertain as occupational requirements, our information indicates continuing strong needs for engineers trained in the new technologies, for well-trained scientists with graduate degrees, and for new science faculty members to meet the rapidly growing requirements of colleges and universities. Recruitment of engineers on college campuses during the past spring was reported at record levels. It should perhaps be emphasized that a gap between the industrial needs for engineers and the number of new graduate engineers in 1970 will not necessarily be evidenced by a corresponding number of unfilled jobs. The situation will more likely be an adjustment in job requirements which will permit the utilization of nongraduates with less adequate training.

H-7. With the advent of the space age the charge has been made that rapid development of space technology has drawn many of the best professors, practicing engineers and students away from aeronautical engineering into the more intriguing and glamorous field of space engineering, research, and development. Is this true? And if so, is it cause for concern? Is any program in existence or contemplated to assure a balanced input of graduate space scientists and aeronautical engineers into the scientific and technological communities?

There is no doubt that the expansion of the space program of the Federal Government, first in fiscal year 1959 and again at a higher level in fiscal year 1962, created increased requirements for scientific and technical personnel throughout the economy. However, these requirements for personnel were not in direct proportion to expendi-

tures, because of the higher cost per technical man in these programs. Furthermore, the expansion in the early years of the program was offset somewhat by decreases in expenditures made by the Department of Defense for research and development programs. In summary though, the increases in the space program together with the growth in other Federal programs and the general expansion in the economy have resulted in greatly increased needs for scientific and technical personnel.

In answer to the more specific aspects of the question; namely whether the *best* personnel have been drawn away from *aeronautical* engineering to space work, very little is known about the movement of professors and practicing engineers. On the supply side, degrees granted in aeronautical engineering have in general kept pace with trends in other engineering fields; at the graduate level aeronautical engineering has kept ahead of most other branches.

We have tried (but without great success) to find ways of characterizing movements of personnel on the basis of quality. At present there are no generally acceptable quantitative measures to determine the ability of scientific and technical personnel, which can be used to identify the "best" persons. Furthermore, the factors affecting career and even specific employment choices relate to immediate financial gains (including prospects of support as students), long-run career opportunities, opportunities for stimulating work and professional advancement, and even geographical considerations.

There is no overall plan at the national level, either in the Federal Government or elsewhere, to provide for a "balanced" input of trained personnel into specific programs. Activities in the Government and other sectors of the economy are determined on their own merits and in the case of most programs decisions are made on a decentralized basis to advance individual missions and goals. However, the Federal Government, through the Office of Science and Technology, the various individual agencies, and the Congress is continually reviewing various programs to detect gaps and to stimulate activities where such motivation is indicated.

(See also E-13.)

I. Supplemental Questions

I-1. Assuming that NSF budget and responsibility accelerates to the extent that our hearings suggest, this would seem to require that you preserve and increase the scientific standing and competence of your senior staff. Will not this require (1) an increase in senior staff, and (2) additional delegation of authority in the manner in which Cabinet members now delegate authority to Assistant Secretaries, etc.?

I-1. Whether or not NSF budgetary and programmatic responsibilities increase at a rate faster than they have heretofore, we must of course agree with the idea that substantial increases in the size and in the "scientific standing and competence of [NSF] senior staff" will be required in the years immediately ahead. It has been my aim since I became Director of the Foundation to avoid unnecessary increases of personnel. Through various reassignments of responsibility and through the elimination of certain staff elements which were deemed no longer essential, it has for some 2 years been possible for us to absorb an increasing workload with very little increase in staff size. However, it is clear that the work we now face, in attempting to accomplish the tasks I have earlier outlined for the subcommittee, will require a larger staff. In particular, we will have to recruit a number of individuals at a fairly senior level; this will clearly entail corresponding increases of support personnel at lower levels.

As I testified on August 19, it is my intention to carry forward soon plans for additional delegations of authority which have been materializing for some time. When Reorganization Plan No. 5 was allowed by the Congress to come into effect on July 27, 1965, certain ambiguities were removed as to my freedom to delegate to others those actions which had been placed within my purview by specific resolutions of the National Science Board. Thus it is my intention to assign both responsibility and authority to associate directors for dealing with certain grants below a specified size. Already the associate directors are primarily responsible for a wide range of matters relative to the recruitment and training of full-time employees; the securing of consultative services; liaison with coordinate groups in other agencies of Government and with appropriate nongovernmental bodies; approval of studies to be carried out by NSF or by contractors; determination of the need for and duration of travel on the part of staff members; and a number of comparable matters. (Obviously, all those concerned recognize that special cases which arise—even within relatively clear-cut assignments such as these—are to be brought to the attention of my deputy or myself.)

No one can appreciate more fully than I do the desirability—indeed, the necessity—of moving as far and as rapidly as possible to delegate to the appropriate organizational level all elements of authority that can, with propriety and within the broad constraints of good management, be assigned to others.

I–2. Section 3a(2) of the National Science Foundation Act directs the Foundation "to appraise the impact of research upon industrial development and upon the general welfare." What has NSF done and what is it doing to carry out this directive?

I–2. In carrying out the functions described in section 3a(2) of the National Science Foundation Act, the Foundation has borne in mind the great breadth of this provision of the act and the need to stimulate scholarly inquiry into this subject throughout the country. It has obviously been necessary to be selective in exploring various aspects of the effect of research upon the general welfare and, more particularly, upon industrial development.

Activities have, accordingly, been organized which balance continuing intensive effort in some areas with exploratory projects in a number of other directions where inquiry by other interested groups can be stimulated. These activities comprise surveys of research and development, special economic studies, and conferences on research and development.

The various surveys and studies of research and development expenditures and manpower all provide a statistical background for measuring the "impact of research upon industrial development and the general welfare." The Foundation has a regular series of studies and surveys designed to make available information on the deployment and utilization of scientists and engineers in industry and the other sectors of the economy. In addition, the Foundation has sponsored studies by the National Bureau of Economic Research, the Engineers Joint Council, and the Bureau of Labor Statistics to appraise the manpower supply in relation to anticipated requirements with particular emphasis on research and development scientists and engineers. The National Register of Scientific and Technical Personnel has made possible numerous studies relating to the characteristics of scientists and engineers, including their training, work activities, type of employer, income, and mobility.

A continuing study of particular significance is the annual survey of industrial research and development which was first sponsored by the National Science Foundation in 1953. This survey[1] has been conducted annually since that time, except for 1954 and 1955. The questions, definitions, and instructions in the survey have been developed by the National Science Foundation in consultation with Government, university, and industry officials. The individual questions are designed so as to pick up information on changing patterns of industrial research. The survey provides the following R. & D. data by industry and size of company on a regular basis:

(1) Funds for basic research, applied research, and development;

(2) Sources of industrial expenditures (Government and industries' own funds);

(3) Product areas of research; and

(4) Fields of basic research.

Additional data are provided on research contracted to outside organizations, such as other companies, commercial laboratories and consultants, educational institutions, nonprofit research institutes and

[1] The Foundation provides the financial support for the data collection, but the Census Bureau carries out the survey.

foundations financed by industrial firms; research and development by major type of expense; and number of R. & D. scientists and engineers.

New inquiries have been added to the survey questionnaire from time to time for the purpose of developing special data required for Government policy planning. Recent examples of such questions are (*a*) R. & D. expenditures by State and geographical division, and (*b*) the number of R. & G. scientists and engineers and the associated R. & D. costs for personnel working in industry on NASA and DOD contracts.

Thus, the annual industrial survey is rich in providing background information on the "impact of research" because of the close relationship between industrial research (particularly company financed) and technological change that arises through the introduction of new products and processes. The data from the industrial survey together with those from other surveys sponsored and conducted by the National Science Foundation, find frequent use in both the legislative and executive branches of the Government as well as in industry itself.

While the annual industrial survey provides a framework for appraising the changing patterns of industrial R. & D. activities, special studies have been designed to probe deeper into special problem areas of research and development.

Many of these studies were instrumental in suggesting new areas for further research and analysis by other investigators. An indication of the growth of interest in this type of research may be gleaned from the NSF publication "Current Projects on Economic and Social Implications of Science and Technology." In 1959, this publication listed 96 studies being conducted at universities and colleges related directly or indirectly to the "impact of research." In the most recent edition of the publication—1964 (in print)—the number of studies listed was 405.

"Role of Research and Development and Technological Change (Innovation)": A series of studies, conducted under contract and resulting in the publication of three reports ("Reviews of Data on Research & Development," No. 31 (NSF 61–52), No. 34 (NSF 62–16), and No. 38 (NSF 63–12)), examined the relation between a firm's output of important innovations and the size of its R. & D. expenditures, interfirm diffusion of technological change, and differences in the adoption of innovations by firms within selected industries.

"Decision Making on Research and Development in Industrial Firms": This study, also conducted under contract, provided information on the factors affecting R. & D. spending in industrial firms, firm behavior with regard to decisionmaking, R. & D. budget allocation, and project selection processes. The findings of the study were published in Reviews of Data on Research and Development, No. 44 (NSF 64–6).

"Allocation of R. & D. Resources Within a Company": The contractor of this study, by using operations research techniques, made a pioneer case study for the purpose of providing guidelines for the difficult problem of optimum allocation of research and development resources within a company. The findings of the study were published in the December 1962 issue of IRE Transactions on Engineering Management.

"Special Reports on Individual Industries": The National Science Foundation has prepared and published analytical reports on three individual industries—aircraft and missiles, chemicals and allied products, and electrical equipment and communication—each of which accounts for a relatively large share of the dollar volume of total industrial R. & D. performance. These reports, published in the series "Reviews of Data on Research and Development" (No. 39, NSF 63–19 and No. 42, NSF 63–41), and in "Reviews of Data on Science Resources," (No. 3, NSF 65–3), provide background information on research orientation in the particular industry as well as an analysis of various R. & D. data related to that industry.

"Special Report on Research and Development and the Gross National Product": The National Science Foundation prepared a report comparing R. & D. expenditures to the national accounts including both private product and Government product to provide a basis for viewing the level of R. & D. expenditures in relation to the Nation's total annual economic expenditures. This report was published in "Reviews of Data on Research and Development," (No. 26, NSF 61–9).

"Relationship of Statistics on Research and Development to Other Economic Variables": The results of a special study of what is planned to be a sequence of studies was published recently in the Foundation's report "Industrial R. & D. Funds in Relation to Other Economic Variables." This study compared and analyzed data on research and development with several other economic variables, such as employment, payrolls, sales, value added by manufacture, and new capital expenditures in both companies with R. & D. programs and companies not reporting R. & D. programs. A second phase of this study will be undertaken in the near future as data from the 1963 Census of Business, Manufactures, and Mineral Industries become available. Availability of these data will make it possible to extend the number of statistical relationships in terms of time series presentation.

"Analysis of Regional Patterns of Research and Development and Science-Based Technology": A study conducted under contract is currently investigating the regional patterns of research and development and science-based technology. The study will provide a detailed analysis of existing care studies of the effects of R. & D. concentration in local areas and interactions with research-based industry; initiate and complete intensive case studies of three other areas (Santa Clara County, Calif., the urbanized area of the northern part of Utah and Winston-Salem, N.C.); and assess the local impact of research and development and research-based activity, as reflected by the case studies.

"Research and Development in Smaller Manufacturing Firms": Completion of this study in the near future is expected to yield valuable information and data about the factors which limit participation of small firms in R. & D. activities. The annual NSF surveys of industrial research and development clearly demonstrate that small firms, as a group, perform less research and development relative to the size of their operations than do larger firms. The study will also examine various approaches to stimulate research and development in small firms and enhance their growth potentialities.

In addition to the studies described above, which have either been completed or are in process, the National Science Foundation is planning to undertake in the near future several other special studies of a comparable nature. Thus there has, since 1953, been compiled a growing amount of information on the nature of the U.S. commitment to research and development and the relation of that commitment to industrial development and the general welfare. A broad basis for understanding these relationships has been developed, but much more needs to be done to provide the specific details which will enable effective planning to meet future needs in a rapidly changing technology.

I-3. Would there not be an advantage, from the standpoint of too much inbreeding of the Government-science relationship, if members of the National Science Board did not serve simultaneously on the President's Science Advisory Committee?

I-3. In my opinion, the simultaneous service of a few members of the National Science Board on the President's Science Advisory Committee constitutes an advantage to the National Science Foundation. The National Science Board has 24 members from outside the Government and the number of these members who also can serve concurrently on the President's Science Advisory Committee is of necessity extremely limited. There is no problem, therefore, of the possible imposition of the views of the President's Science Advisory Committee upon the Science Board. Rather, such membership on both bodies affords an opportunity for close liaison and heightened interchange of information and ideas. The particular experience and broad knowledge gained by service on the President's Science Advisory Committee by a few Board members adds an extremely valuable input into the deliberations of the Board. Personally, therefore, I believe such simultaneous membership—so long as the overlap in membership is small, as it always has been—serves a very useful purpose and enhances the effectiveness of the National Science Board without in any way affecting its independence.

I-4. You have indicated ways in which the Foundation is able to check the quality of research projects and of educational grants and fellowships. However, how does the Foundation check on the quality of its summer institutes? Is there any specific mechanism set up for this purpose?

I-5. What evidence do you have that the majority of the summer institute programs for teachers is effective?

I-4. The Foundation has devoted a great deal of attention to—and has spent substantial sums on—the evaluation of the quality and effectiveness of its summer institutes. No other activity of NSF has had as much effort devoted to its continuous assessment. Several specific mechanisms—some continuous and some ad hoc—have been set up for this purpose.

A regular cycle of site visits to institutes while they are in operation is carried on annually, employing members of the staff plus about 45 consultant scientists. An attempt is made to visit all new institutes and to visit continuing institutes every second or third year. During the summer of 1965, 331 of the 616 summer institutes received a visitor. Typically the visitor spends about 2 days at an institute, and not only checks on its quality and on the reactions of the participating teachers, but provides helpful guidance and counsel so as to help improve the

quality of the institute through application of ideas which have proved useful in other institutes.

That the vast majority of the summer institutes are effective is clear in the reports of these visitors. Through their contacts with faculty members and with groups of participants they report accomplishments in the increase of the teachers' knowledge of subject matter, and their appreciation of its potential application in improvement of their teaching of science. Seldom is a report received of any institute which is not judged effective, although their effectiveness does differ in degree.

No precise measure of the impact and efficacy of a specific institute can be provided, because of the difficulties of establishing a norm for comparison and of separating the effect of institutes from the concurrent effects of course content revision, of the general post-Sputnik increase in interest in science, and of the changing teacher population. However, much evidence of specific effects is available to back up the statement of Dr. James B. Conant in his 1963 book, "The Education of American Teachers."

I–5. The use of NSF summer institutes for bringing teachers up to date in a subject-matter field has been perhaps the single most important improvement in recent years in the training of secondary school teachers.

An early statistical study was conducted in 1960 by the Bureau of Social Science Research, Washington, D.C. This study was centered on a group of 538 teachers from 503 high schools who attended summer institutes in 1957. In 251 of the schools, interviews were conducted in the fall of 1959 with principals or supervisors and with teacher colleagues of the 1957 institute participants. Approximately five out of six principals said they would consult a former NSF summer institute participant rather than another teacher when they wanted advice on new teaching techniques; three out of four said a person who had attended an institute would be given preference in assignment to a new subject. Principals also expressed strong preference for institute-trained teachers for assistance in selecting new equipment and textbooks, acting as advisers to science clubs, and serving as representatives at teachers' conferences. Participants themselves summed up the institutes' effects in the following manner: More than 80 percent said they learned new subject matter; almost 40 percent said they learned new techniques of teaching their subject; more than 33 percent gave the institute credit for their assignment to teach more advanced sections; more than 25 percent said the institute was a source of added enthusiasm or improved self-confidence; 20 percent said they had profited from the program by widening their social contacts.

On their return to their classrooms, many participants said they made changes directly as a result of their institute experience. Almost half said they introduced more advanced subject matter into their courses or broadened their coverage; about 30 percent said they brought newer subject matter into their courses; about 30 percent said they also put more stress on student participation through such devices as encouraging special projects; and about 16 percent said they were devoting more time to laboratory work and making greater use of audiovisual aids. One key finding in this study was that institute attendance had a definite cumulative effect. Of the teachers who

attended only one institute, 32 percent reported "a great deal" of improvement in their course work. The same response was given by 41 percent of the teachers who had participated in two institutes and by 59 percent of attendees at three institutes.

One measure of the effectiveness of summer institutes is their continuing, and increasing, attraction of teachers in numbers far exceeding the opportunities available:

Participation in NSF summer institutes for secondary school teachers, 1961–65

	Applications	Applicants	Participants
1961	175,860	55,714	18,812
1962	184,161	56,294	20,267
1963	176,939	56,555	20,450
1964 [1]	188,000	56,900	20,550
1965 [1]	197,700	59,400	21,350

[1] Estimated.

Another measure of the effectiveness of the institutes program lies in the evaluation by the directors of the individual institutes of their own achievements. Many directors collect written, unsigned, commentaries from their participants, and report quite uniformly on the favorable reactions of a large majority of the participants. These favorable reactions, combined with the continuing enthusiasm of their faculty colleagues who teach in the programs, cause over 90 percent of these directors to submit proposals for subsequent institutes.

The effectiveness of institutes in improving secondary school education in science and mathematics should appear in the increased capabilities of high school graduates for college work. Many college and university staff members have commented on the observable changes in their entering classes—changes they feel are attributable, in part, to the institutes attended by the teachers of these students. For example, Dean B. Roger Ray of Washington State University, has stated:

> The [NSF] institute program has been more responsible than any other factor in achieving a substantial upgrading of competence of science and mathematics teachers in secondary schools. I believe it has been the primary factor. We continually see the results in general and specific ways. Each freshman class in the university is better prepared in science and mathematics than the previous one, for instance, as shown by our mathematics placement test scores. These students are getting instruction in their basic high school courses that is more substantial and modern. We have an increasing number of freshmen who obtain advanced placement, in good part because additional science beyond the minimal requirement is being offered in the high schools by competent teachers. Frequently we can correlate the quality of the work given in a high school with a specific teacher who has participated in the institute program.

The Congress itself has recognized the effectiveness of the institute programs of the Foundation by using them as models for the institute programs of title VI of the National Defense Education Act of 1958 and title XI of the 1964 revision of the same act. These legislative enactments resulted from strong pressures from the educational world for teacher training opportunities in the nonscience areas to match the evident successes of the institutes in science.

An address of Dr. Samuel Schenberg, supervisor of science for the New York City schools, to the 1962 convention of the Association for

the Education of Teachers in Science summarizes the view we have encountered in many situations:

The National Science Foundation, through its sponsorship of summer institutes and revisions of existing courses of study on a nationwide basis, is making a highly significant contribution to the improvement of science and mathematics teaching in the junior and senior high schools of our country. The impact of these programs is already influencing the offerings of our colleges in the freshman year. In a brief period of a half dozen years the NSF by virtue of the tremendous financial resources at its disposal has demonstrated that a national agency can raise educational standards in every city and hamlet in the United States without infringing upon the rights and control of local school systems.

Thus we can say that formal evaluation devices, informal assessments, reactions of informed observers, and testimony of participating teachers and their supervisors all contribute to the continuous review of this program—and all these mechanisms point to the conclusion that this has been and remains an important and effective way of improving the scientific potential of the Nation.

I–6. In regard to NSF support of engineering, you have provided evidence to show that NSF's approval of engineering proposals and fellowships is roughly in the same ratio as its approval in the area of the physical sciences. However, the total support of the physical sciences far exceeds that of engineering. In view of the Gilliland report which emphasized a nationwide need for more engineering Ph. D.'s, do you think NSF's effort here is adequate? Should it not consider the national picture rather than just the percentage of the Foundation's own support for engineering?

I–6. In my reply to question E–19, I expressed the Foundation's general agreement with the recommendations of the Gilliland report. At the same time, I pointed out some important related matters with which the report did not deal, and the need for periodic examination and reassessment of the problems inherent in the area of scientific manpower.

In its support of engineering, as in all fields, the Foundation has consistently tried to evaluate the needs and opportunities presented on a nationwide basis. Several factors are of special significance in the case of engineering and have to be borne in mind in evaluating the Foundation's position.

1. The mission-oriented agencies, especially the Department of Defense, NASA, and AEC have direct and continuing interest in the support of engineering research. Whereas support in certain fundamental fields of science by DOD, for example, has been questioned, there has never been any doubt about the Navy's long-term commitment to the support of research in hydrodynamics and naval architecture. Furthermore, many research workers in these fields prefer Navy support, since the Navy is a primary user of new information. A highly satisfactory relationship has developed between the Navy and research workers in these areas. The same can be said of the relationship of mission-oriented agencies to engineering research activities in material sciences, aerodynamics, nuclear engineering, and many other fields. The Foundation must evaluate its role with a clear appreciation of the mutually advantageous relationship which exists between the other agencies and engineering research workers.

2. Engineering education for the past 10 years has been in a state of agonizing reappraisal. The Foundation has been watching this

process and has supported a Commission on Engineering Education, comprised of leading representatives of the profession, which is seeking to resolve some of the major problems now being faced by engineering schools. The Foundation has also made grants (to the American Society for Engineering Education) for major reassessments of the goals of engineering education, and means of achieving these goals. The report of this study has not yet been completed, but it will undoubtedly contain recommendations which if widely adopted will have substantial influence on the future of engineering education at both undergraduate and graduate levels.

3. Although the Foundation has adopted a broad definition of basic research in engineering, it is not possible under the limitations of our act to support some of the activities in engineering schools in the areas of applied research and exploratory development. In the NSF fellowship and traineeship programs, however, support for graduate students and advanced scholars is available in all areas of engineering.

The rapidly increasing production of engineering doctorates now being achieved with existing support (the annual production of engineering doctorates has approximately doubled since 1961) will undoubtedly lead to increased needs for research support in the future. About one-third of the new doctors of engineering are entering the teaching profession as young faculty members, thus swelling the clientele seeking research assistance from NSF. It is therefore probable that the need for university research support in engineering will increase rapidly in the next few years.

Since 1960 our support of project research grants in engineering has risen faster than our support in any other area (except for the social sciences). As the table we presented to the subcommittee on August 19 shows, we are currently providing more support to graduate students in engineering than we are to all the physical sciences combined. Moreover, our various surveys show that other agencies provide large amounts of support for engineering research and graduate students.

In summary, then, in relation to the overall resources available to the Foundation and its presently assigned mission, we consider that the proportionate support currently being given to research and education in engineering by NSF is appropriate. The rate of increase of research support is commensurate with the increasing needs viewed at the national level, but may need to rise in a few years. We remain ready to support more good work of high quality in engineering research, and we confidently project continued increases of our support in this important area.

I–7. In the consideration of NSF fellowships and traineeships, is personal need ever considered as part of the criteria for approval?

I–7. Personal need has not been and cannot legally be considered as a criterion in the selection of NSF fellows, since the Foundation's enabling legislation makes it clear that fellows are to be selected "solely on the basis of ability."

If we wished to make a distinction between "selection for award" and "determination of the amount of an award," it would be possible to award fellowships to the ablest applicants, but then to apply some kind of "means test" in each individual case in determining the amount of the fellowship award in that specific case. The National Science

Board has on occasion considered and discarded this possibility. The Congress arrived at a similar conclusion when it specified that all NDEA fellows were to receive the same basic stipend. As a general matter, we know of no major Federal or private fellowship program administered on a national basis which—apart from providing standard dependency allowances—applies the criterion of personal need in determining the amount to be awarded a graduate student chosen for a fellowship.

With respect to the Foundation's traineeship program initiated in fiscal year 1964, universities receive grants which enable them to appoint individuals to traineeships and it is possible that some universities take financial need into account in selecting individuals to hold these awards.

In both the NSF graduate fellowship and graduate traineeship programs the stipends and dependency allowances provided by the Foundation are identical. Each program has a permissible feature, however, which allows the universities to consider the financial need of fellows and trainees and to supplement their stipends from university funds. We know that—on occasion—universities have supplemented stipends based on the need of individuals. It is our view that the specific need of individuals for any financial assistance beyond the Foundation's basic stipends and dependency allowances can be determined best by the universities. Our policy has been to establish guidelines which will permit universities to make that decision at the local level.

I–8. In your reply to question B–6, you emphasized the 15-percent annual growth for academic research refers to the total Federal support rather than, to that of NSF alone, and that the NSF academic research budget would have to be further increased if the other departments and agencies do not sustain this rate. Because a small reduction of large mission agency research budgets could require a relatively large NSF offsetting budget increase, one can foresee requests for NSF academic research to grow at annual rates of 20 or 25 percent, which correspond to doubling times of 4 and 3 years respectively. What effect do you think such a growth rate for academic research would have on other NSF programs? Could the NSF properly administer such rapidly growing programs without major changes in organization and staffing?

I–8. Growth rates of the order of 20 to 25 percent per year in NSF support of academic research are by no means unprecedented. We do not have the specific analysis on the basis of academic research alone, but NSF support of basic research in general (most of which went to universities and colleges) rose 49 percent in fiscal year 1962 over fiscal year 1961, 37 percent in fiscal year 1963 over fiscal year 1962 and about 24 percent in fiscal year 1965 over fiscal year 1964. Thus increases of the order of 20 to 25 percent per year would not appear particularly difficult to manage effectively, although some modifications in procedure and in organizational patterns are most likely to be necessary in the future as they have been in the past. The Foundation has continually revised its procedures and its organizational structure as NSF activities have become more complex and extensive; if the Foundation is given responsibility for serving the "balance wheel" function envisaged in question I–8, I would expect that still further changes will eventually be required.

Growth rates of the order of 25 percent annually in the support of academic research should (for a time at least) be paralleled by sizable but not necessarily comparable growth rates in the other programs of the Foundation.

In my reply to the question cited above (B-6, combined with E-7, E-6, and C-6), I dealt at some length with the factors which must be considered in assessing future needs for support of education in the sciences, major research facilities and new or refurbished research laboratories.

There we pointed out the difficulty of devising a specific annual-rate-of-increase criterion for these areas of concern. We have much the same difficulty with respect to our support of national centers, national research programs, science information activities, and the like. Our past experience indicates unequivocally, however, that major increases in all these areas are highly desirable for at least a few years to come. I have no hesitancy in saying, therefore, that substantial increases in academic research should be made along with increases of a similar nature—based on specific justifications in the particular program at issue—in all of the Foundation's activities. To move forward with such increases in academic research support without correspondingly higher levels of support in other programs—or at their expense—would be to solve one problem by creating others.

As I have already indicated (above and in answer to question I-1), we will certainly have to consider new procedures, new organizational arrangements (including additional delegation of authority), and additional staff if the Foundation continues to grow in the future as it has in the past. I do not look upon these matters with any degree of alarm, however, for they represent a situation with which the Foundation has been grappling—with reasonable success—since its earliest days.

I-9. Considering recommendations to enlarge different parts of the NSF budget, or to shift emphasis within programs, would you briefly describe how the final allocation is reached in your budget requests between you as Director, the National Science Board, and your senior program staff? To what extent do the Bureau of the Budget and the OST change or cause revision of individual programs, or activities within program estimates?

I-9. As part of the budget formulation process, the staff members responsible for the program activities of the Foundation develop preliminary estimates of the funds required in their respective program areas. These estimates are reviewed by the Associate Directors and forwarded to my office. At this stage a series of discussions take place, with participation by the Deputy Director, the Associate Directors, the Comptroller, and the Budget Officer, to evaluate the program requests in relation to each other and within the general guidelines of the Bureau of the Budget.

At the point where we are reasonably satisfied that the budget request as a whole is well balanced, taking into account the needs of the various programs, we present this preliminary budget to the National Science Board. This presentation is the occasion for Board discussion of budget levels, program emphasis, relative needs, and new activities to be undertaken. The preliminary budget request is then submitted to the Bureau of the Budget for review and approval.

A major concern of the Bureau, obviously, is the total of the budget request. In addition, however, both the Bureau and OST take an interest in and discuss with us specific aspects of our activities. These discussions may result in increases or decreases for specific items as well as in the overall total. The amounts finally agreed upon are incorporated in the President's budget for submission to the Congress.

When the appropriation bill is passed by the Congress, the Foundation is required, as is every other agency, to submit a request to the Bureau of the Budget for an apportionment of the funds appropriated. The allocations to the various programs and activities are discussed with the senior staff, and my recommendations are then communicated to the Bureau of the Budget.

As part of my report to the National Science Board at each meeting, I normally include a statement advising the Board of the status of our budget request, allocations made, and major changes in emphasis among programs.

I–10. What other mechanisms, other than project evaluation by peers, might be experimented with to avoid overloading the scientific community with reviews while preserving their input into the selection process?

I–10. Although we consider project evaluation by peers to be an essential part of any process of making research grants, there are a number of ways in which the burden on the scientific community can be lightened. Among these are:

1. Prescreening of proposals is carried out by NSF staff to eliminate many proposals that are incomplete or obviously not worth reviewing because of low quality.
2. The number of mail reviews for any proposal is normally limited to three except in exceptional cases.
3. In a number of areas review by assembled panels has been limited to those proposals which are marginal in quality or have some unusual features, decisions on others being made by the NSF staff.
4. For long-term continuing programs, a full-scale review will be required only at 5-year intervals. Intermediate decisions will be made by NSF staff.

Most scientists welcome the opportunity to participate in the review process, either as mail reviewers or as members of assembled panels. When this work becomes burdensome to any individual, our staff members take steps to reduce his load. In general, we feel that a healthy relationship exists between the Foundation and the scientific community in this area.

Although we have found no substitute for the proven project evaluation by peers, we have sought and are finding (though not for the primary purpose of reducing the workload on reviewers) means of research support other than the traditional project grant. For example, "coherent area grants" are made which provide support for a number of related projects which are jointly reviewed, evaluated, and funded, thus reducing the overall total in reviewing time and effort. Institutional base grants provide assistance to an entire institution. These grants, as we have noted in other contexts, lead to an entirely different basis for distributing funds in support of academic science, and do not require any time on the part of external reviewers.

These other methods of funding science must not be considered in competition with the project support method. We believe that several support techniques of a complementary nature are desirable. The mechanisms just described, however, require a different system of evaluation and reduce the burden on scientific reviewers. The project basis of support and the evaluation by peers, however, provide a unique method which we do not think can be supplanted by other methods of evaluation and review. We nonetheless are acutely aware of the need of holding to the absolute minimum the amount of external review effort we request of the scientific community, and we intend to continue our search for ways of reducing the burden of such work on those to whom we turn for help in this area of our operation.

I–11. Considering the effect of the quality of Federal administration upon academic research, to what extent should the Foundation lead Federal agencies in the simplification and standardization of rules and regulations governing grant and contract administration? For example, Dael Wolfle pointed out recently that the NIH grant manual is more than 100 pages long.

I–11. Since the Federal Government is the chief source of support for the vast bulk of academic research, it is clear that the manner in which the Government administers its grants and contracts can exert a major impact on the conduct of academic research. From the time of its establishment to the present, the Foundation has been well aware of this important relationship and has attempted to carry out its administration of grants and contracts with the minimum of interference in the course of research, while at the same time assuring the adequacy of necessary fiscal and administrative controls.

Recognizing the importance to academic institutions of grant and contract procedures that have been simplified and standardized to the maximum extent possible, the Foundation has continually attempted to "streamline" its own procedures. Because of its unique responsibility for the broad-scale support of basic research, the Foundation believes it should exercise a leadership role (working in consultation and cooperation with other Government agencies) in developing simplified, standardized procedures governing grant and contract administration.

As a recent example of its activities along these lines, the Foundation is presently engaged in developing a new research grant report to take the place of the grant fiscal report currently required of grantees. The new research grant report has been developed in such a way that it could be adopted by other agencies, and the Foundation has been in consultation with the Bureau of the Budget regarding eventual Government-wide adoption of this reporting procedure.

The Foundation's efforts along these lines, as question I–11 recognizes, can be effective only to the extent that NSF patterns or suggestions are viewed by other agencies as worthy of adoption, because we have no authority to impose uniform practices on other agencies.

Response by Dr. Donald F. Hornig, Director, Office of Science and Technology, to Questions of the Subcommittee on Science, Research, and Development

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1. In your statement on June 29 you testified as follows:

Major problems lie ahead which will call for stepped-up efforts to develop new and improved approaches to the planning of the Government programs for the support of academic research and for relating this research to the large science programs aimed at particular national objectives.

What major problems of this sort do you foresee?

1. The major problems which lie ahead are of the following types:

A. To meet the growing needs of the country for research and education in the sciences. Essential parts of this problem are to determine, on a geographical basis, the distribution of facilities for scientific research and education which are needed to meet social and economic needs of regions as well as the Nation as a whole; to determine how support should be allocated among universities to meet regional needs while at the same time assuring that high quality in academic research is not only maintained but enhanced and expanded.

B. To develop methods to choose meaningfully among the growing number of opportunities for further research which the present research uncovers.

C. To use research to meet the growing needs of our society for answers to questions which we now believe should be solved by national action.

2. What is the precise difference between the functions of the Federal Council for Science and Technology and the Office of Science and Technology? Do not these organizations have virtually the same personnel which also includes being active with the President's Science Advisory Committee? If this is so, is this the most efficient manner of getting a job done?

2. The Office of Science and Technology, the Federal Council for Science and Technology, and the President's Science Advisory Committee serve distinct but related functions. OST is a part of the Executive Office of the President, and its primary task is to assist the President on all matters relating to science and technology. A secondary task is to provide staff for PSAC and FCST. The function of the PSAC is to provide advice to the President by highly qualified scientists who are, with few exceptions, not associated with the Federal Government. The function of FCST is to provide a two-way link between the policy officials responsible for the major Federal R. & D. programs and the President and his office. These functions and their relationships are described below.

The Federal Council for Science and Technology is an interagency committee consisting of policy-level representatives from all the major R. & D. agencies. Its primary function is to provide a mechanism for

the coordination of R. & D. programs and policies cutting across the responsibilities of several agencies, to serve as a forum for the discussion of common problems, and as a source of recommendations to the President through its Chairman. The FCST is an advisory committee without executive responsibility, although by reaching agreement through consensus it often makes decisions in fact. The recommendations of the Federal Council incorporate the views of the agencies represented on the Council on policy matters affecting them. It both originates policy proposals, and reacts to proposals arising from other sources. In addition, the Federal Council provides a central mechanism for the establishment of interagency coordinating groups, of which there are nine, and for assessing the effectiveness of these groups.

The Office of Science and Technology under the leadership of a Director who is also the Special Assistant to the President for Science and Technology, is a part of the Executive Office of the President. As such, the primary function of the Office is to provide advice to the President on questions relating to science and technology. Many questions of science policy are not appropriately dealt with either by the Federal Council or the President's Science Advisory Committee in spite of the breadth of their activities and influence. Some of the most significant questions affect only one or two agencies, and are therefore not effectively handled by the Council. Other questions are of such a nature that the advice of PSAC is not directly pertinent. Many problems of interest to the President must therefore be handled within his Executive Office. For example, those aspects of the Federal budget affecting science and technology are reviewed within the Executive Office of the President, including participation by the Office of Science and Technology, after the primary proposals have been made by the agencies and after advice has been received from many sources. This direct involvement in decisions made by the President and within his Executive Office distinguishes the work of the Office of Science and Technology from the two advisory groups. In addition, the Director of the Office of Science and Technology testifies before Congress as a spokesman for the administration on matters affecting and affected by science and technology.

The Office of Science and Technology provides the Executive Secretary for the Federal Council for Science and Technology and for the President's Science Advisory Committee. In addition, the staff of the Office of Science and Technology provide data, draft materials and general assistance to the two advisory groups. This method of operation serves to provide effective communication and division of effort between the groups involved, but it does not weaken the essential distinction between them.

3. You spoke of the Federal Council for Science and Technology as "an indispensable forum." What has been the frequency of meetings of the Federal Council, by fiscal years, since 1960?

3. The number of formal meetings of the Federal Council for Science and Technology have been as follows:

Calendar year:	Number
1960	11
1961	10
1962	12
1963	12
1964	13

The committees and panels of the Council serve to extend the forum function by broadening the range of subjects considered, expanding the detail of consideration and extending the number of people involved. In fiscal year 1964, 89 meetings of the 11 Federal Council committees were held, and the panels of these committees held approximately 250 meetings.

In addition to its own meetings and those of technical committees and panels, the Council has used other groups to amplify the forum function. For example, the standing committee of the Council, which pays particular attention to the effectiveness of the Federal laboratories, has a major function—the sponsorship of symposia on factors affecting laboratory operation. Each of these symposia has drawn together about 100 persons with responsible positions in the management of R. & D. laboratories. Most of those who attended were from outside the Washington area.

The first symposium, held in October 1963, dealt with current problems in the management of scientific personnel. The proceedings were later published.

A second symposium, held on April 13–14, 1964, reviewed the technical information role of the Federal laboratories.

The third symposium held on December 7 and 8, 1964, dealt with the environment of the Federal laboratory and management problems in the Federal service. This symposium, like the first in the series, was jointly sponsored by the Federal Council and the Civil Service Commission.

The actions recommended at the symposia are now under study by the FCST Standing Committee, the Civil Service Commission, and the agencies concerned.

4. Should the National Science Foundation have broader authority to act more as an operating agency? If so, why?

4. The primary mission of NSF is to insure the health of basic research and scientific education throughout the country. Its underpinning of basic research and education can be accomplished most effectively through support of the universities using the grant or contract mechanism. However, in support of its primary mission it supports extensive extramural operations such as NCAR and the Mohole project.

At the present time I am not in favor of in-house laboratories in NSF for the conduct of basic research. On the other hand, an operating role of this kind for NSF in the future should not be precluded as a possibility if required to meet special needs that cannot be met otherwise. However, this should not be allowed to detract from its support of basic research in the universities.

5. Is the Foundation's role in shaping, coordinating, and evaluating national science policy—or rather, its lack of a role in this matter—a healthy arrangement?

5. Before answering this question directly I should like to make clear that there is no such thing as a single national policy for science. National science policy is composed of a mosaic of related segments.

The NSF has an important role in the shaping and evaluation of a number of these segments of national science policy. It has a unique responsibility among the Federal agencies for the advancement of basic science, per se, including education for science. Thus, in formu-

lating its own programs in science and science education, the Foundation must take into consideration the support programs of other agencies and their cumulative effects on the universities. The NSF is expected to and does generate policy proposals for the entire Government which are given particular weight because of the unique position and mission of the agency. The function of generating policy proposals is different from that of assisting the President in achieving coordinated Federal policies for the promotion of basic research and education in the sciences. The latter function was assigned to the Director, Office of Science and Technology by Reorganization Plan No. 2 of 1962 because it was recognized that this task can be effectively carried out only from the Executive Office of the President. Separation of those two aspects of policy—initiation as contrasted with establishment and execution—tends in fact to strengthen the policy role of NSF.

6. Are too many Federal agencies today involved in supporting basic science grants and science education? Is there duplication here? Might not the Foundation assume a more central, if not exclusive, role in this regard? Who coordinates this area?

6. We do not believe there are too many Federal agencies involved in supporting basic science grants and science education. Indeed we feel that the national interest would be served if certain other agencies not now much involved in the support of extramural research were to increase their involvement in basic and applied research outside the Government through the support of selected projects in universities and other research organizations in fields appropriate to their mission. For example, the Departments of Interior and Commerce are less than optimally effective in fulfilling their missions because they do not have sufficient interaction with the general scientific and engineering community outside the Federal Government. Diversity of support is important in insuring that research opportunities are not overlooked, and that parochial biases which inevitably develop in individual agencies will be canceled out in the overall picture. The argument for diversity applies to private, State, and local, as well as Federal sources of support.

There are two reasons to support basic scientific research, based on the needs of society. The first relates to the internal needs of science and of science education as determined primarily by areas of scientific knowledge. The National Science Foundation supports research primarily on these terms. The second is embodied in the missions of the various Federal agencies, and depends upon the fact that progress toward many well-defined national goals is limited by the lack of basic knowledge and understanding about certain groups of scientific questions. Support of basic research thus constitutes an essential part of the national programs in health, defense, and space. Because the line between basic and applied research is constantly changing and new opportunities are constantly emerging from basic research, these agencies cannot depend exclusively on another agency to support the generation of the knowledge they may need. They must not only keep in contact with the best thinking going on in the universities and elsewhere, but also encourage through support of basic research the growth of certain broad areas of knowledge in accordance with priorities related to their own mission and not just the development of science and education. Duplication need not exist if the programs are effectively

coordinated. Furthermore, the nature of basic scientific research is such that professional penalties are attached to duplication, whether unwitting or not, and the system of project selection by panels of peers further tends to detect and eliminate potential duplication.

The greatest danger of duplication may occur in the case of classified material which is not exposed to open scrutiny and criticism. The likelihood of this occurring is greatest in in-house laboratories.

OST is charged with coordinating research and development activities. One of the largest and most difficult questions is what activities should be coordinated and to what extent. Agency heads and other senior officials confer with each other and with personnel of the Executive Office of the President, as appropriate, on major policy questions and on projects involving large sums of money. At the working level, frequent contacts assure coordination between agencies, as for example NSF and NIH through meetings of program directors and exchange of information among them. The Science Information Exchange is another mechanism for coordination and avoidance of duplication.

In those agencies in which project and program review is carried out by panels of peers such as study sections, an effective means exists for avoiding duplication. This mechanism is used in NSF and NIH.

It is conceivable that NSF might take a larger role for the whole Government in coordination and prevention of duplication but I question whether this course would be wise.

7. Have our science programs been effectively utilized to further the U.S. position internationally? Should NSF assume a more active role in the support of international science programs?

7. Science and technology have a large role to play in furthering the foreign policy objectives of the United States. The problems which involve science and technology are more or less universal in character and provide a basis for mutual understanding and for cooperative action that often transcends political differences.

International cooperation in the field of science and technology is pursued in a wide variety of ways and through many channels. Many such activities are conducted through the medium of intergovernmental programs, involving a number of different U.S. Government agencies according to their spheres of interest. The Atomic Energy Commission, for example, is engaged in a number of cooperative activities related to atomic energy pursuant to bilateral agreements under the atoms-for-peace program, including arrangements with Euratom and the International Atomic Energy Agency (IAEA). AEC also carries out exchange programs with the Soviet Union. The Department of Defense provides funds for basic and applied research under cooperative agreements entered into with friendly governments, particularly those of Europe. The National Institutes of Health have supported health research programs in many countries. The Department of the Interior engages in cooperative programs relating to natural resource development. The Agency for International Development undertakes programs for institution building in areas of science and technology as part of its developmental programs for newly developing countries.

The Department of State has found various ways of utilizing science and technology to promote better international relations. The exchange agreements with the Soviet Union which are under the

supervision of the Department of State, have contributed to the improvement of international understanding, and the scientific exchanges under the agreements have made a significant contribution to this result. The United States-Japan Committee on Scientific Cooperation is another example of the cultivation of better international understanding through science. In both of the activities of the Department of State just listed, the National Science Foundation has played an important role, through the funding of certain of the scientific exchanges with the Soviet Union, in the one case, and through the support of the United States-Japan Committee, in the other.

Another form of international cooperation in the field of science and technology is conducted by international organizations. American scientists and representatives of American governmental agencies participate in a number of scientific and technological undertakings sponsored by the various technical agencies of the United Nations, such as the Food and Agriculture Agency (FAO), the World Health Organization (WHO), the World Meteorological Agency (WMA), the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and others. The U.S. Government also participates in scientific programs of regional international bodies such as the Organization for Economic Cooperation and Development (OECD), the North Atlantic Treaty Organization (NATO), and the Organization of American States (OAS). These activities on the part of the U.S. Government fall under the direction of the Department of State with support derived from a number of other Government agencies that are concerned.

The National Science Foundation has lent support to U.S. participation in a number of international scientific exercises and operations, such as the International Geophysical Year, the International Indian Ocean Expedition, the International Hydrological Decade, the International Year of the Quiet Sun, the upper mantle project and the antarctica program.

The United States has also contributed to the support of a number of nongovernmental international scientific bodies, such as the International Union for Pure and Applied Chemistry and the International Union for Pure and Applied Physics, which are grouped together in the International Council of Scientific Unions (ICSU) on which the United States is represented by the National Academy of Sciences.

Mention should also be made of the innumerable contacts that are made in the field of science and technology directly between scientists in research laboratories in universities and in private industry, and through attendance at scientific meetings of varying degrees of specialization sponsored by governments or by the governmental and nongovernmental international technical organizations referred to above. The fostering of personal relationships between scientists in the fields of basic research and applied technology is essential to the wider application of scientific progress and the development of better international relations. The importance of the role of the National Science Foundation in providing travel funds which enable U.S. scientists to participate in such international meetings and to develop useful contacts abroad merits recognition.

In summary, the total effect of this wide range of activity on the part of agencies and organizations within the U.S. Government in the

field of international science and technology has been clearly beneficial and is making a significant contribution to the achievement of U.S. foreign policy objectives.

The full potential of science and technology as a means of promoting international understanding and good will has not yet been realized. We are constantly seeking better ways to improve our international relations through science.

The National Science Foundation has played an important part in the accomplishments in respect to international science programs carried out to date. We hope and expect that the NSF will also look for ways to develop new and improved programs to achieve our objectives in the area of international science.

8. Have Government-wide standards been established for scientific fellowship awards and stipends? If so, who establishes them and what are the standards?

8. Government-wide standards for fellowship awards and stipends have not been established formally. However, levels of support for the basic stipends and allowance of most predoctoral and postdoctoral fellowships generally exist through understandings among the agencies concerned. These levels are agreed on administratively. The small variations that exist derive in part from differences in congressional authorizations.

Predoctoral fellowships presently provide between $2,400 and $2,800 for a full year of academic study (depending upon the number of years past the bachelor's degree) plus $2,500 to the institution to cover part of the costs of education. The National Defense Education Act predoctoral fellowships whose stipends and allowances are set by law also conform to this pattern; NASA provides an additional allowance which may be used to increase stipends in certain circumstances and pays the full educational costs to the institution.

Beginning in 1952 the NSF coordinated the stipends and allowances through annual and later semiannual consultation with the agencies granting fellowships. More recently the Bureau of the Budget has requested the Commissioner of Education to assume this task in view of the Office of Education's broad responsibilities for educational policies.

I believe that there should be room for experimentation in the granting of fellowships. This has been possible under existing arrangements with the elimination of inequities accomplished by administrative consultation.

9. How can the relatively low science education budget of the National Science Foundation act as a balance wheel against the large sums spent in institutions of higher learning by mission-oriented agencies? Should not the NSF have a say in how all Federal basic research funds are allocated—because of their close link to science education?

9. It is difficult for the NSF to balance fluctuations in support by other agencies when its budget is such a small proportion of the total support for science and technology. We would like to see its proportion increased somewhat. NSF should have some concern and interest in other agency programs in order to do its own job effectively. NSF can assist in identifying areas of research opportunity, but the allocation of funds to meet the technological purposes of another agency is best decided by that agency with policy guidance from the President.

The present system of interaction between the universities and the agency is the best guarantee that other agency programs will also help education.

Data gathering and analysis by NSF is of the greatest importance in obtaining a comprehensive picture of university support by mission-oriented agencies. This function needs to be steadily improved if distortions or gaps are to be detected and remedied. In this respect NSF plays a crucial role in the process of determining and analyzing allocation of funds for the support of basic research.

10. Do you consider the present balance between project support and institutional support by NSF to be satisfactory?

10. Throughout the first decade following its establishment NSF engaged predominantly in project support. This was a logical and necessary response to both needs and opportunities. In recent years there has occurred a significant evolution with the support of broad programs of science and education, and institution building through the award of development grants. Institutional grants have important implications for the future development of science and education especially through the creation and strengthening of centers of scientific excellence in all regions of the country. I believe that this program should be expanded in the future, but not at the expense of project support which is essential not only for the advancement of scientific knowledge but also for the education of the oncoming generations of students. On the basis of careful estimates and forecasts it has been calculated that for the near future the needs of basic research and scientific education can be adequately met only if there is an annual increase in the funding of academic research. I believe that these estimates are sound and that this annual increment is necessary if we are to maintain our scientific leadership and give full opportunity to our youth.

11. In relation to scientific and technical information, who decides to make the allocation as between Federal and non-Federal data? What is the authority for this decision?

11. The answers to this question are subsumed under the response to other questions. We are omitting it, therefore, from this submission. (Mr. Knox of this office and the staff of the subcommittee have agreed on this procedure.)

12. The National Academy of Sciences in its recent report, "Basic Research and National Goals," emphasized 15 percent annual increase for support of basic research. Where will the support for the increased student body and the needs of institutions come from? Should one put priority in the increase in funding for basic research ahead of increased funding to meet student enrollments? With this Federal support doubling every 5 years, won't other sources of university funding shrink rapidly in proportion? Is this good? Is this the result of a policy study? If so, is it available?

12. A major portion of the extra funds for growth of basic research are used to provide significant research opportunities for new faculty, for graduate students, and other trainees and increasingly even selected undergraduates, as university enrollments increase sharply. In general, funds for formal instruction—including classrooms and faculty expenses—are easier to obtain from non-Federal sources than are funds for research. Funding for the capital needs of institutions will be

further aided by the Federal facility programs which normally call for matching. Funding for research needs of the increased graduate student enrollment will help meet the needs for undergraduate students by freeing resources which the institutions would otherwise be compelled to devote to research. Whether an additional Federal role for meeting undergraduate research needs is called for deserves careful consideration by the Congress and the Executive.

There is no evidence that the increase in funding which has occurred in the past has caused absolute shrinkage of other sources of support, although the proportion of Federal funds in the educational system has increased. The 15 percent growth requirement for academic research implies an annual increase of $150 million as compared with an annual increase of over $1 billion which has occurred for all forms and sources of support for higher education. We agree that it is important that non-Federal sources of support continue to grow, so that the institutions of higher education in this country do not depend too exclusively on Federal funds. In point of fact, non-Federal sources of support for science and science education are continuing to increase substantially.

Comprehensive current national figures are not available at the present time. A survey of sources of support on a sampling basis was carried out by NSF in 1958. During the past year NSF has made a national survey, institution by institution. Preliminary results will be available in 6 to 8 weeks but analysis will not be completed for approximately 6 months.

For some years NIH has conducted surveys of the national expenditures for medical research. The figures shown in table I indicate that for this very large segment of research support the infusion of extensive Federal funds has not caused private support to dry up. Instead, private support has increased more than six times the level of support in 1947. The expenditures by industry, which are chiefly, but not exclusively in-house, have increased by approximately twelvefold during the same interval.

TABLE I.—*National expenditures for medical research, 1940–64* [1]

[In millions]

Sources of funds	1940	1947	1957	1959	1960	1961	1962	1963 (estimate)	1964
Total	$45	$87	$440	$648	$845	$1,045	$1,290	$1,470	$1,672
Government	3	27	239	368	471	604	819	969	1,102
Federal	3	27	229	351	448	574	782	924	1,052
State and local	(2)	(2)	10	17	23	30	37	45	50
Industry	25	35	126	190	253	312	336	360	415
Private support	17	25	75	90	121	129	135	141	155
Foundations and health agencies	12	15	42	49	76	77	78	79	90
Other private contributors	(2)	(2)	5	10	12	15	18	21	22
Endowment	5	10	19	19	19	19	19	19	19
Institutions' own funds	(2)	(2)	9	12	14	18	20	22	24

[1] Covers only medical and health-related research; such activities as research training and construction are not included. Beginning with 1960, data for the non-Federal component have been improved and therefore are not strictly comparable with those for prior years.
[2] Not available.

13. The point has been brought during the hearings that certain research projects are referred to the National Science Foundation by other Government agencies. This raises the question of how one deter-

mines if a certain research project should be funded, say, by agency X, agency Y, or both. More specifically:

(a) What guidelines or criteria has your agency established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the agency's jurisdiction and, therefore, should, or should not, be supported by the agency?

(b) If written criteria have been established, please submit a copy thereof to the committee.

13. On small projects, decisions as to whether funding is appropriate for a certain agency depends on a decision by a program officer as to the relevance of the proposed project, the funds available, and the rest of the program supported by the agency. In the cases of major programs, such as large telescopes, high energy accelerators, oceanographic ships, decisions are made by the President in conjunction with affected agencies. The decision is made on the basis of relevance to a particular agency program, and a judgment as to the experience in management of the agencies involved.

(*a*) OST has not set up general guidelines or criteria to aid grant or contract administrators to determine whether particular research projects should be supported by a given agency. One can define areas of science that are related to the missions of an agency but those may overlap particularly in the case of basic research that is broadly relevant to an agency's mission. As noted in the reply to question 6 mechanisms exist to minimize duplication of effort. A more difficult problem is to assure that important areas of science do not go without support because they are not directly relevant to the mission of an existing agency.

(*b*) Written criteria have not been established.

14. What agency of Government, if any, has responsibility for the coordination of Federal research and development in the three fields of air pollution, soil pollution, and water pollution? Is such coordination a proper role for the National Science Foundation?

14. The Clean Air Act, as amended, gives explicit instruction to the Department of Health, Education, and Welfare for coordination of Federal research and development in the field of air pollution. Water pollution control is also vested in the Department of Health, Education, and Welfare, but the congressional mandate for coordination of research and development in this field is somewhat less clear. At the present time work going on or supported by several agencies involves research on the effects of water pollution. Health, Education, and Welfare does maintain awareness of other research and there appears to be little overlap. No agency has specific legislative authority for soil pollution research and development. Work that is carried out at present is mostly within the Department of Agriculture or under its general cognizance. Some small amounts of research related to the effects of soil pollution, especially on micro-organisms, may be carried out in other agencies.

Coordination of research in the three fields of air pollution, water pollution, and soil pollution would not appear to be an appropriate role for the National Science Foundation. Enforcement responsibility for control of air and water pollution is vested in Health, Education,

and Welfare and development work associated with pollution abatement seems most appropriately located in the organization with enforcement responsibility. Research on the effects of pollutants would seem to be best left in the agencies responsible for the resources affected. For example, effects on human health in the Public Health Service, effects on fish and wildlife in the Department of Interior, effects on domestic animals and crops in the Department of Agriculture. Little overlap is likely to occur since the responsibilities are quite different in each agency. It is possible that there may be problems that are so extensive in scope that they do not fall to any single agency and thus are not considered by any agency.

Most areas of pollution research and development are problem oriented and would be foreign to the usual activities of NSF in support of basic research and science education.

15. You stated that NSF is the only agency with a broad enough interest to undertake a central planning responsibility for tying together the separate agency systems for assembling and disseminating scientific information. (You used the analogy of the Bell System tying together many independent telephone companies.)

(a) Would you please discuss in greater detail exactly what you had in mind and how it compares to what the NSF is doing in this area now?

(b) Would it require a change in NSF legislation?

(c) Could it include privately owned data gathering services?

15. It is too early to discuss in greater detail the specific functions envisioned for an agency which would have a central planning responsibility in tying together the separate agency systems for disseminating scientific information, and for recommending actions for the nongovernmental sector. Our ideas in this connection will become clearer when two contractual studies presently underway unde the auspices of the Committee on Scientific and Technical Information (COSATI) of the Federal Council for Science and Technology are completed within the next 5 months. Until that time, it is not possible to determine whether a change in NSF legislation would be required. The responsibilities for overall planning, organization, and evaluation of the Federal Government's information programs, however, are so demanding that it is unlikely that the existing NSF organizational structure would provide an adequate mechanism for discharging these responsibilities. A central planning responsibility would of necessity include privately operated services which constitute such a large segment of total scientific information activities.

16. When the NSF was created in 1950 with a budget limited to $15 million, the National Science Board could, presumably, exercise close supervision over the workings of the Foundation. Since that time, the budget of the Foundation has increased to about $480 million, and the Board has delegated much of its authority to the Director, keeping for itself the authority for major policy decisions. In effect, then, the Board serves as a sort of Board of Governors, and is the only such nonregulatory agency with this form of dual (Board and Director) authority and responsibility. The question then arises, Is it in the best interest of the country and of science in general to still maintain this dual authority, or would it perhaps be better to have the Director solely responsible for the operation of the Foundation, and

have the Board serve in an advisory capacity to the Director (a National Science Advisory Board)?

16. The membership of the National Science Board has performed important functions in the formulation and implementation of the programs of the Foundation. It brings to the Director diverse points of view and experience from a variety of institutions and organizations outside of Government essential to the development of balanced programs. Clearly, if it were not established as a governing body, there would need to be created an advisory committee to the Director. While there is no evidence that the Board's authority for major policy, program, and budgetary decisions has impeded the initiative or effectiveness of the Director, it is appropriate for consideration to be given to the possibility of recreating the Board as a statutory advisory committee appointed by the President.

The statutory status and Presidential appointment of the Board have facilitated recruitment of outstanding public members and their investment of substantial time in Foundation affairs. During the past 2 years the Board has undertaken studies in depth of policies and long-range plans that should guide the activities of the Foundation, and we regard this as a welcome expression of the Board's involvement in strengthening the role of the Foundation in assuring the health and vigor of American science.

17. An early policy of the Foundation was to use grants to broaden the geographic distribution of support funds to many more institutions than those primarily supported by other Federal agencies. Early grants for research facilities, however, were made to major centers (Harvard, MIT, Michigan, etc.)

(a) Should the Foundation devise and adopt a deliberate policy of distribution that is counter to that of other Federal agencies?

(b) Has the situation in U.S. science changed sufficiently over 15 years that the Foundation should today avoid support of existing centers of excellence?

(c) Would the impact of the Foundation be greater under such a policy?

17. (*a*) When the NSF was established there was a pressing need to build up our national capabilities in basic research as rapidly as possible consistent with the requirement that only work of high quality would be supported. It was natural and proper, therefore, to build strongly on existing foci of excellence in our leading institutions, while at the same time, through project support to highly qualified investigators in institutions throughout the country, to create new foci of excellence.

We are now in the process of developing centers of scientific excellence on a national scale, building on the programs of NSF, NIH, and other agencies. The science development program of NSF has made development awards to 10 institutions during the past fiscal year (Case Institute of Technology, Western Reserve University, University of Oregon, Washington University, Rice University, University of Arizona, University of Colorado, University of Florida, University of Rochester, University of Virginia).

I do not believe that NSF should adopt a policy that is counter to that of other Federal agencies, but rather that advantage should be taken of the programs and resources of other agencies to work collabo-

ratively with NSF in developing new centers of excellence as well as strengthening existing institutions.

(*b*) Since the existing centers of excellence set the standards of quality and produce the people that migrate all over the country to staff other universities and industry, and since the new knowledge they produce is readily available nationally, I do not believe that existing centers of excellence should be penalized in the competition for Foundation funds for research where scientific merit is the major criterion for choice. When programs for adding additional centers of excellence are involved, then, of course, the major centers should not be considered.

(*c*) If the Foundation had a policy of not supporting excellence wherever it existed, I believe the effect on the quality of U.S. science would be disastrous, and the source of high-quality people to staff the developing centers would also dry up. The open competition for project grants purely on the basis of quality provides a standard against which we can measure our success in building new centers and against which university administrations can judge the quality of their own institutions and identify their own strengths and growing points.

18. Associated Universities, Inc., operates the National Radio Astronomy Observatory on a cost-plus-fixed-fee contract. Similarly, University Corporation for Atmospheric Research and Association of Universities for Research in Astronomy, Inc., also not-for-profit organizations, operate National Center for Atmospheric Research and Kitt Peak, respectively.

(a) What special competence do these not-for-profit organizations have to operate and manage these centers?

(b) Should the Foundation operate these centers as in-house laboratories?

18. (*a*) Associated Universities, Inc., had shown competence in the management of Brookhaven National Laboratory for the Atomic Energy Commission when it was chosen to manage the National Radio Astronomy Observatory. The other two corporations were set up on the successful pattern of AUI to manage NCAR and the Kitt Peak National Observatory to assure that the users of these facilities for basic research would have a voice in their management and also to provide the necessary flexibility so that these expensive installations can be responsive to the needs of the scientific community for facilities of high quality.

(*b*) All the centers operated under contract for NSF were created partly to serve the needs of the university scientific community, from which a substantial fraction of the users of the facilities are drawn on a visiting basis. It would be more difficult to provide flexibility of operation and the necessary responsiveness to the needs of the user community were the facilities operated as in-house laboratories. There are no successful precedents for in-house operations to serve purposes of this nature and it seems unwise to depart from a successful pattern of operation which enjoys the strong support of the academic scientific community which it is designed to serve. The experience of the AEC in broadening university representation in the management of the Argonne National Laboratory and in developing plans for management of the proposed 200-billion-electron-volt accelerator are further precedents having relevance in this connection.

19. Scientific talent in Government is concentrated, of course, in the executive branch. Do you believe that the scientific disciplines, including mathematics and engineering, should have more representation in our legislative bodies? Has any effort been made by anybody to attract more scientists and engineers into politics? How might we go about inducing technically trained people to run for public office?

19. A wide range of talents is obviously desirable in the membership of our legislative bodies. However, I do not believe that because a person has a scientific background he is therefore peculiarly qualified as a legislator. This is true of legislation within his own area of scientific knowledge and more so in other areas where he is as much a layman as anyone else.

I do not believe we should try to induce technically trained people to run for public office unless they have qualities over and beyond their scientific background which qualify them to serve. Within this framework, however, I believe that legislators of high scientific and technical competence can make significant contributions to the deliberations of the Congress.

20. What function does the Science Information Council perform? Does its function conflict with those of the Committee on Scientific and Technical Information?

20. According to title IX of Public Law 864, 85th Congress, the duty of the Science Information Council is "to advise, to consult with, and to make recommendations to the head of the Science Information Service." The functions performed by the Council follow the statute very closely. The Head, Office of Science Information Service, seeks the advice of the Council on many matters of interest to his office.

The functions of the Science Information Council (SIC) do not conflict with those of the Committee on Scientific and Technical Information. The functions of SIC are to consider matters of interest and concern to the National Science Foundation; the functions of COSATI are to consider matters of interest and concern to the entire Federal Government.

21. Users of scientific information seem to be confused as to what Federal resources are currently available to them. Would the National Science Information System be more effective if the numerous and varied existing Federal scientific information centers were consolidated in one location?

21. I do not believe it is desirable to consolidate in one location the various Federal scientific information systems and services because it is highly unlikely that consolidation would result in more effective interaction between the user and the information source. An information system should not be thought of as a repository service which passively links facts to people who need them. Information transfer is an active and not a passive process. There must be extensive interaction between provider and user. This is well demonstrated by the effectiveness of oral communication which is efficient because it is pointed and directly responsive to queries.

Consolidation would also be undesirable because scientific information needs a focus in the agency charged with its development and diffusion in response to the needs of a particular user clientele, whether governmental or private.

In this vein it may be observed that the existence of the Library of Congress with its extensive collections and comprehensive cataloging does not diminish the need for many other libraries, both general and specialized, in universities, in industry, and in communities.

22. Both the National Science Foundation Act of 1950 and the National Defense Education Act of 1958 avoided any mention of "coordination" of the scientific information activities as a responsibility of the Foundation. The Presidential Scientific Advisory Council report of January 10, 1959, the January 22, 1959, letter of the President, and Executive Order 10807 of March 13, 1959, specifically recommended and assigned coordinating responsibility to the Foundation.

(*a*) *Was there a difference of opinion during this period between the Congress and the Executive Office as to the viability of an assignment of coordinating responsibility to the Foundation?*

(*b*) *Was any attempt made in the executive branch during this period to define what was to be meant by "coordination" of science information activities?*

(*c*) *Did the Foundation make any effort to discharge the Presidential assignment of coordinating responsibility or did it simply continue to follow the statutory authority given it by the 1950 and 1958 legislation?*

22. Although the National Defense Education Act of 1958, title IX, did not mention "coordination" of scientific information activities as a responsibility of NSF, the concern of the Congress during 1958 for a more effective, coordinated system of scientific and technical information within the United States was frequently expressed. (See especially hearings before Senate Committee on Government Operations on S. 3126.) The climate of opinion generated by the launching of Sputnik I in late 1957 was highly favorable toward a single agency undertaking a coordinating role within the executive branch in scientific and technical information. Upon recommendation of the President's Science Advisory Committee on December 7, 1958, the President directed that NSF take the leadership "in bringing about effective coordination of the various scientific information activities within the Federal Government." This directive was in line with the prevailing thought both within the executive branch and in the Congress during this period.

During the initial years of the Office of Science Information Service within the National Science Foundation, considerable efforts were made to define its role in "coordination" of science information activities. On several pressing problems, such as translations and the establishment of a page charge policy, NSF took the leadership within the executive branch. In effect, NSF coordinated Federal agency information programs with respect to these two specific areas. In other specific areas, such as dissemination of federally produced technical reports, coordination by NSF proved unworkable. This was mainly due to the diversity of statutes for the principal research and development agencies, directing them to provide for effective information acquisition and dissemination in relation to their missions.

A subsidiary but not unimportant factor was the difficulty confronting a small, newly established agency in attempting to coordinate the information activities of large, mission-oriented agencies.

With the establishment of the Federal Council for Science and Technology and its Committee on Scientific and Technical Information, renewed emphasis was given to interagency program coordination.

23. What was the purpose of giving the weather modification program to the NSF in 1958 rather than to some other Government agency?

23. Considering the state of the science of weather modification, and the capability of various agencies to manage research programs in this field, it was advisable to give the responsibility to NSF at that time. A research program rather than an operational program was clearly indicated.

24. From the standpoint of objectives, program control, and management, which of NSF's programs do you consider to be the best? Which the least useful? What are the Foundation's notable weaknesses or deficiences, and how may they be corrected?

24. The programs of NSF are under continuous review by the National Science Board, which in consultation with the Director, must make decisions as to the priorities of programs and their level of support. I believe that this system, coupled with "peer group" assessment of individual projects and programs, has enabled NSF to maintain high standards of quality in the work it supports. There is no evidence known to me which would indicate that there are variations in quality among programs. Because its funds have always been limited, NSF has of necessity centered its support on high-quality projects.

The weaknesses in the NSF program are a reflection of the state of national planning for the support of research and scientific education. NSF cannot remedy apparent deficiencies singlehandedly except to a limited degree because many agencies of Government as well as the whole private sector are involved.

It has been charged that NSF has not been vigorous enough in forward planning. In recognition of the needs during the past 2 years the planning unit has been reorganized and one of the three major committees (III) of the National Science Board has concentrated on long-range planning.

Among the greatest weaknesses of NSF have been insufficient funds and personnel resources to carry out the directions laid down in the act which established the Foundation.

Response by Dr. Frederic Seitz, President, National Academy of Sciences, to Questions of the Subcommittee on Science, Research, and Development

1. Would you comment on the interrelationship between the National Academy of Sciences, the National Science Foundation and the President's Science Advisory Committee—where members of the Academy may also be officials of NSF or its Board and/or members of PSAC? Is there not a relatively small group of people here who control a good deal of what research is or isn't supported by NSF?

1. Since membership in the National Academy of Sciences is determined on the basis of elections held by its membership in such a way as to single out a segment of those most proficient in scientific work, it is not surprising that the same individuals will be found in a number of posts requiring outstanding qualities based in science. Thus, the President's Science Advisory Committee is made up almost entirely of academy members. Many Academy members serve on the Science Board of the National Science Foundation. Similarly, a number of distinguished Government officials holding positions in which profound knowledge of science is vital to their work are members of the Academy. I do not believe that this should be regarded as surprising or unnatural in any way. Members of the Academy, of course, have a profound dedication to science and its progress which guarantees, in effect, that a certain fraction of them will be asked to serve the Government in a variety of ways. Since competence and talent are limited in any society, it is inevitable that a few scientists will be asked to serve in more than one way. Examination will show that such individuals invariably have remarkable talents, exceptional experience, and unusual dedication.

In relation to the dangers that might be associated with such overlap of responsibility, it should be emphasized that most decisions reached by the advisory groups on which Academy members serve are made as result of extensive debate involving many individuals with a wide variety of viewpoints. In my own experience, I have seen no instance in which a person of this caliber serving on several advisory committees has shown any significant tendency to bias his recommendations. On the contrary, persons serving in several capacities are usually those whose advice is most valuable. They usually come to the conference table with the broadest perspective.

2. The National Academy of Sciences has done much to establish America's eminent position of scientific technology. Have our great achievements in science since World War II enhanced our country's position in world leadership generally—for example, politically or socially? If so, in what manner and to what extent?

2. Prior to World War I, the United States was admired abroad for having produced many brilliant inventors and technological innovators, but we were regarded as backward in basic science. There was, in

effect, a large differential in science between the United States and certain countries across the Atlantic Ocean. Between World War I and World War II we edged ahead in basic science because our educational system was basically sound, our ideals were on the whole excellent, and both private and State money became available in increasing amounts for basic science. In addition, the refugee scientists from Western Europe acted as catalysts in an inherently healthy system. The great technological achievements of World War II on this side of the Atlantic, followed by the generous support of science by the Federal Government during the last 20 years, had the effect, judged by almost any standard, of moving our science to the front ranks, a fact realized throughout the world. Broadly, in many countries, the United States is regarded as a leader in world science. There is no doubt that our position in science has greatly enhanced our status abroad politically because of its implications of power.

The world leadership of the United States is recognized not only in the physical sciences that contribute to the advancement of technology but also in the life sciences on which depend the constant improvement of agricultural and medical practice. Progress in the life sciences in the past half century has provided the means to bring under control the mass infections and nutritional diseases on a global basis and has actually achieved this control in the more advanced countries. The result has been that in these countries the problems of medicine have shifted from the diseases of infancy to those of the degenerative diseases in an aging population, and the protection of that population from the stresses of urbanization and of a technological environment.

It might be added that leadership in research cannot be achieved without an excellent educational system, particularly at the graduate level. U.S. accomplishments in science are, I believe, recognized as testimony to our system of education and the access it has afforded to our young people from a wide variety of backgrounds who wish to pursue careers in science.

3. How do we determine the future long-range demand for scientific manpower so as to assure meeting this demand through the support of science education? What are the basic problems in meeting our national goals on science manpower? Which agency should be responsible for maintaining statistics on scientific and technical manpower?

3. It is my personal opinion that since our science-based technological society is becoming ever more complex and sophisticated, we shall need all the highly trained talent in science and engineering that we can produce. A study of university enrollments shows that the fraction of students going into science and engineering is not increasing significantly with the passage of time. This means that the supply of good scientists and engineers is and will be sharply limited. Nationally, we should do whatever we can to encourage good students to advance to the Ph. D. level or its equivalent in graduate science and engineering. My personal opinion is that such a program will return both tangible and intangible dividends to our Nation.

The basic problem in achieving our national goals in science manpower apart from money, which is not necessarily the biggest obstacle at present, is that relatively few men and women have talent for and

interest in science and engineering, coupled with the incentive to invest the many years of arduous work needed to become highly proficient.

It seems to me that the National Science Foundation, the National Institutes of Health, and the National Academy of Sciences should work in cooperation with other agencies to maintain statistics on scientific and technical manpower. Each of the three organizations will furnish its own particular viewpoint and contribution to the study of manpower. In addition, the Office of Science and Technology should maintain a deep interest in correlating and analyzing the results of such manpower studies.

4. Is there significant degree of competition in our universities between the science research laboratory and the classroom for the services of our best scientists? Do you see any danger of turning our colleges—that is, their science and engineering departments—into great research laboratories and away from education institutions?

4. In the range of my experience scientists in universities have a deep interest in educating the young, and thus take their classroom work very seriously. Since our society is a very complex one, placing heavy demands upon our good scientists and engineers, most outstanding faculty members have a variety of responsibilities. In addition to classroom teaching and research, they often have responsibilities in university administration and to their local governments and the Federal Government. In addition, some may be called upon to advise industry and other private organizations in ways that obviously advance the national welfare. I believe that matters are reasonably balanced at present and that most outstanding faculty members spend about as much time in the classroom as the conditions of the day permit. Obviously, the situation is not perfect. It might be improved if the good scientists found it possible to spend somewhat less time making certain that the contract support they receive is continued as agency policies change from one period of time to another. This, however, is an exceedingly complex issue which should be reviewed in a broad and comprehensive way.

Above all, I should like to stress the fact that any move to "send the professors back to the classroom" by "cutting out their research" would be sheer folly. Good academic research, which is closely linked to the teaching responsibility at present, is absolutely indispensable to the welfare of our society. Any studies of ways to make the faculty scientist more effective should focus upon techniques for aiding him in both teaching and research, since the two are intimately coupled.

5. What is known about the size and makeup of that segment of the population qualified for careers in science and engineering?

5. This question has been the subject of formal study only in recent years. The first such study was made by the Office of Scientific Personnel of the Academy-Research Council about 1947 under a small grant from the Rockefeller Foundation. Somewhat later a much broadened study, under a substantial grant from the same source, was carried on under the direction of Dr. Dael Wolfle, with additional sponsorship by the other three research councils [1] constituting the Con-

[1] The American Council on Education, the Social Science Research Council, and the American Council of Learned Societies.

ference Board of Associated Research Councils. The result was a landmark report entitled, "America's Resources of Specialized Talent."

With the advent of the National Science Foundation, a source of support and a center of interest and responsibility for manpower studies was established as a part of the Foundation structure. The focus of such responsibility in the Foundation is the Office of Economic and Manpower Studies. Through this Office, the Foundation has funded a number of projects aimed at providing basic statistical information on the scientific and engineering manpower pool, its characteristics, its magnitude, its growth, and its utilization.

The Foundation has recently combined two series of publications, Reviews of Data on Research and Development, and the Scientific Manpower Bulletin into a new series entitled "Reviews of Data on Science Resources," which provides the most recent data in a concise form and on a continuing basis.

One of the responsibilities of the Foundation is the maintenance of the National Register for Scientific and Technical Personnel. This register, administered in cooperation with the appropriate professional societies, is an invaluable source of information about our scientific and engineering manpower resources.

It is of interest to note that the Carnegie Foundation and the Russell Sage Foundation are providing support for the establishment of a new Commission on Human Resources which will have as one of its main purposes the further exploration of such questions as the potential supply of scientists and engineers, their intellectual attributes, and their motivation toward careers in science and engineering.

6. What studies are the Academy or NSF sponsoring to provide more information about the nature and rate of obsolescence for scientists and engineering personnel, and about effective countermeasures?

6. It is probably true that the gravity of this problem is increasing at a greater rate than are the efforts to analyze and alleviate it.

One of the more specific considerations of the problem in a formal way was carried out by a Committee on Utilization of Scientific and Engineering Manpower established by the National Academy of Sciences under a grant from the Ford Foundation. This committee, composed of distinguished persons from industry and the academic world, explored the state of knowledge relating to this question and initiated such inquiries as were possible in view of its resources and timespan. The concluding report,[1] published last year, is a mature review of the problem with a number of significant recommendations for action. Among other non-Government groups deeply interested in this problem are the Engineers Joint Council and the American Society for Engineering Education.

The National Science Foundation is certainly aware of the need for a better understanding of the problem of scientific and technological obsolescence. This is evidenced by their recent support of an exploratory study at Case Institute of Technology which has led the Foundation to consider a full-scale study of this important problem.

It is of interest to note that one conspicuous geographical focus for this problem is in southern California where the earlier concentration of aerospace activities and the recent slowdowns in these industries

[1] "Toward Better Utilization of Scientific and Engineering Talent: A Program for Action."

has created pools of unemployment. To meet this situation there has been formed, through concerted efforts of industry, the universities, and public offices, a nonprofit corporation, Industry Diversification Institute, which is planning an action program including analysis of the extent and nature of the problem regionally, experimentation and retraining, and assistance in the reabsorption of those displaced back into the labor force.

Within the purview of the National Academy of Sciences perhaps the closest attention to the problem of obsolescence for scientists and engineers will be through scrutiny by the new Commission on Human Resources, referred to above in connection with the response to question 5.

7. Your testimony stressed collaboration in international scientific programs. Should the Foundation assume a more active role in the support of international projects? What do you regard as NSF's proper role regarding initiation, coordination, and funding of international programs in relation to the activities of (a) the State Department, (b) the Federal Council for Science and Technology, (c) the Office of Science and Technology, and (d) the National Academy of Sciences?

7. The Foundation should assume an active role in the support of international scientific projects whenever they relate to basic science and clearly are in the interests of both the evolution of science and the national welfare. The planning and initiation of new scientific programs are complex matters requiring inputs from many sources, both professional and legislative. The National Science Foundation has played a very important role in the process of initating programs in the past; it should continue in this role along the lines it has developed. There will be cases in which the Science Foundation will naturally be the initiator of international scientific programs. Usually it will want and need help from other organizations, such as the State Department, the Federal Council for Science and Technology, and the Office of Science and Technology, which are closely coupled to the Science Foundation as part of the executive structure of the Government and which have a special interest in international science programs. The National Academy of Sciences-National Research Council, being a private organization with a Federal charter, can frequently serve a uniquely valuable purpose by providing advice, either to the Science Foundation or to another agency concerned with such programs. It is my opinion that any given program will be enriched significantly by drawing on a composite of advice provided by all qualified groups that can give it. I believe that the International Geophysical Year was far more successful, because of the close cooperation between the Foundation and the Academy-Research Council, than it would have been if either had attempted to develop the program alone. In brief, I believe the National Science Foundation could and should remain in a position of significant leadership in international programs, but that such programs will benefit if the Foundation seeks companion advice and participation from other organizations, including the Academy.

8. What specific suggestions does the Academy have for the expansion of NSF's role in terms of (a) new fields of science, (b) timetables, (c) organizational changes?

8. At the present time the National Academy of Sciences is carrying through a series of studies of the various fields of science in an attempt to establish priorities within each field that will be of help to the Federal agencies in the planning of future programs. As mentioned in my testimony, these studies are under the guidance of the Academy's Committee on Science and Public Policy, and are funded in part by the National Science Foundation, which has expressed deep interest in the results. It is the opinion of the Council of the Academy that such studies should provide one of the significant inputs bearing on decisions concerning new fields of science, timetables, and possible organizational changes on a national basis. I cannot stress too strongly that the final decisions on all these matters should involve inputs from a number of sources in keeping with our national traditions regarding open discussion.

9. Is there any significance to the fact that the National Academy of Sciences is involved in every one of the Foundation's "national research programs," either as the originator of the program or as a major program coordinator?

9. For somewhat over a century the National Academy of Sciences has drawn on the best available scientific and engineering talent in the Nation to render advice to the Government. In view of this fact it is not surprising that the "national research programs" of the National Science Foundation should involve some significant input from the Academy-Research Council. As I have said earlier, the Academy is engaged in continuing efforts to assist Federal agencies in the planning of their programs. The agencies, I believe, have benefited substantially from such help, in large part because of the experience the Academy has developed in bringing highly qualified professionals together for free and frank discussion of the merits and demerits of various programs, both new and continuing.

10. Are too many Federal agencies today involved in supporting basic science grants and science education? Is there duplication here? Might not the Foundation assume a more central, if not exclusive, role in this regard? Who coordinates this area?

10. Every Federal agency has need for access both to the products of basic science and to the individuals who participate in basic science. Moreover, all agencies have need for qualified personnel trained at advanced levels in science and engineering. I believe it is essential that all the major agencies retain programs that support basic science and related educational activities. This should be looked upon as both normal and healthy. Thus far I have seen no evidence in the period since 1945 of any significant duplication of effort that could be called wasteful. In part, this is a result of the fact that the various agencies maintain both formal and informal links with one another so that each agency is well aware of the support programs of others. Indeed, the existence of support by several agencies provides a pattern of checks and balances that helps to maintain quality in all.

Clearly the National Science Foundation should play a major role in coordinating programs. In the present framework, however, the Federal Council on Science and Technology has assumed the role of a central coordinating body or council among the various executive agencies, including the Science Foundation, which regard themselves as

essentially equal. Taken as a whole, I would not recommend any radical change from the present pattern.

11. In your judgment, should the scientific disciplines have more representation in our legislative bodies?

11. While it is desirable that some legislators should have professional training in either science or engineering to guarantee that the point of view of the professional scientist and engineer will have some direct representation when legislative decisions are made, legislators for the most part will act responsibly, no matter what their professional experience. Legislators can always obtain professional viewpoints directly from scientists or engineers who are not legislators. What is most important, of course, is that they know how to weigh such views and relate them to the national interests.

12. Users of scientific information seem to be confused as to what Federal resources are currently available to them. Would the National Science Information System be more effective if the numerous and varied existing Federal scientific information centers were consolidated in one location?

12. Each Federal agency will automatically be the source of some type of scientific information. The National Institutes of Health will be a source of information in the medical-biological field; the Atomic Energy Commission will be a source of information related to atomic and nuclear science and technology. I am inclined to believe that it is essential to have each agency maintain those centers of information that are closely related to their missions. As in the matter of support of scientific research, the important thing is to have significant coordination between the information centers. Thus, requests from outside directed toward one center may be referred to another if the relevant information is more readily available in the other. The National Science Foundation could well provide a major coordinating service within the executive side of the Government. Indeed, it might be desirable if the National Science Foundation had one or more centers to which inquiries could be directed. I believe, however, that it would be a mistake if such a center had rigid monopolistic control over the dissemination of information. The resultant center would probably have a monolithic quality that would guarantee that it would be relatively ineffective. We do not expect the Congressional Library to be the only repository for books in the country. There is no more reason for having only one information center.

13. How does the Academy reconcile its serving in an advisory capacity to the individual Government agencies and to the President?

13. Whenever the National Academy of Sciences-National Research Council is called upon to render advice to any branch or agency of the Federal Government, a committee of qualified experts is chosen to provide the advisory service. In each case, the committee is furnished with what might be termed the charter associated with the special request, and is asked to follow rules and procedures of conduct in its study that tend to assure objectivity in arriving at conclusions and recommendations. In many instances, individuals who are unusually well qualified serve on two or more of our advisory committees. As I remarked earlier in this series of questions such persons usually are a great asset to the committees on which they serve because of the breadth of their experience and the depth and range of their points of

view. Every effort is made to guarantee sufficient diversity of participation in each advisory committee to minimize the likelihood that any given committee can be dominated by any special interest or interest group. An agency or office that calls on the Academy-Research Council for advice is protected by the fact that the Council of the Academy is exceedingly conscious of the dangers that could arise if any of our committees became strongly biased.

14. What was the role of the National Academy of Sciences in the origin of Project Mohole? What role, if any, does the Academy play today?

14. The Mohole proposal to drill through the earth's crust to the mantle was first made in 1957 by an independent group of earth scientists and engineers gathered under the auspices of what they chose to call the American Miscellaneous Society, or Amsoc, an informal society having no legal or administrative structure. A number of the members of the group were also members of the National Academy of Sciences. They soon became convinced that the project had practical promise, and asked the Academy to assume responsibility for furthering it and for seeking the support of the National Science Foundation. At the end of 1957, the Academy constituted the group as a Committee on the Mohole Project, within the Academy-Research Council structure. This Committee was generally known as the Amsoc Committee.

With the support of the National Science Foundation, and under the guidance of the Amsoc Committee of the Academy in matters of scientific objectives, site selection, drilling techniques, and ship design preparations were made for the first experimental drilling. This was to determine the feasibility of drilling at the bottom of the deep ocean from a free-floating vessel positioned by constant maneuvering with reference to anchored buoys in the open sea. This experimental drilling was carried out with great success off the coast of lower California in the spring of 1961 under the direct supervision of the Amsoc Committee's technical staff. The full report of the drilling is contained in the Academy's report, "Experimental Drilling in Deep Water at La Jolla and Guadalupe Sites," No. 914, dated 1961.

With the end of this experimental phase, the Council of the Academy decided that for the much more extensive next phase, involving the attempt to drill the Mohole itself, the Academy should revert to its traditional role of acting purely in an advisory capacity dealing primarily with scientific questions and objectives, rather than assuming the operational responsibility for a large and complex hardware program. The National Science Foundation therefore set about the task of finding a suitable contractor to carry out the major phase of the project, with the Amsoc Committee of the Academy remaining available for advice. In January 1964, the Amsoc Committee recommended, and the Academy agreed, that the Committee should be disbanded in favor of individual advisory panels on the selection of drilling sites and on scientific objectives. These panels have worked closely in these matters with the personnel of the National Science Foundation and its Mohole contractor.

Response by Dr. Alan T. Waterman, Former Director, National Science Foundation, to Questions of the Subcommittee on Science, Research, and Development

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1. What was the immediate effect of Reorganization Plan No. 2 on National Science Foundation operations?

1. The major effects were:

(*a*) Freedom from responsibility for evaluation of other Federal agency programs as such, thus clarifying a difficulty outlined in my testimony before the Subcommittee on Science, Research, and Development, June 30, 1965.

(*b*) The Director of NSF became a voting member of the National Science Board, ex officio, instead of a nonvoting members.

(*c*) The Director became Chairman of the Executive Committee of the National Science Board, thus strengthening his position with respect to the Board. This provided readier opportunity for the Director to obtain discussion and consultation by the Executive Committee on minor matters or matters for preliminary discussion by the entire Board.

Reorganization Plan No. 2 did not remove from the NSF its authority for developing national science policy. In this respect it merely specified that the Office of Science and Technology have authority to employ such aspects of NSF authorization as needed for purposes of policy determination.

2. Please outline the respective roles of NSF, the National Science Board, the Office of Science and Technology, the President's Science Advisory Committee, the National Academy of Sciences, and the White House in the making of science policy? Where did initiatives arise? Can you give examples?

2. My understanding of the respective roles of these bodies may be summarized as follows:

(*a*) As outlined in its act, the NSF has fundamental responsibility for the support of basic research and education in the sciences (including mathematics, engineering, and social sciences). Among the detailed programs of the NSF for carrying out this mission are the following: Policy planning for basic research centers and facilities, international science activities, research and policy formation on science information matters, research and manpower studies, graduate and postgraduate fellowships and training, improvement of science teaching and science course content, special projects for undergraduate teaching and research, institutional development, and public understanding of science.

The NSF is the focal point in the Government for the initiation of comprehensive programs in basic research for special areas of science and for the receipt of studies and recommendations from the National Academy of Sciences-National Research Council or other scientific

organizations on national and international programs in particular scientific disciplines. For example, it is the Federal agency responsible for the supervision and funding of international basic scientific enterprises such as the International Indian Ocean Expedition, the International Year of the Quiet Sun, and the Antarctic Research Program (the logistic support of the last is the responsibility of the Department of Defense—Navy Department). By amendment to its act it has also been assigned specific responsibility for research on weather modification. By amendment to its act and by Executive order the NSF has increased responsibility for research, studies, and coordination on scientific information matters.

(*b*) The National Science Board has overall policy responsibility for the National Science Foundation and also exercises supervision and control over specific components of the Foundation's programs as stated in its act, notably the approval of fellowships and research grants. By amendment to the National Science Foundation Act these two detailed responsibilities may be delegated by the Board to its Executive Committee or to the Director. Following passage of this amendment the Board delegated this authority to the Director, subject to designated ceilings above which approval of the Board is necessary.

A most important role of the Board is to determine and recommend national policy for the support of basic research and related matters. Among examples have been the following: the assignment of authority and encouragement for the conduct and support of basic research among other Federal agencies, U.S. support of important international science programs, Federal establishment, and support of centers for basic research, loyalty considerations in the case of Federal fellowships in science and the introduction of programs and procedures which set precedents in support of scientific research and education. This authority of the Board may not be delegated to the Director or the Executive Committee.

(*c*) The Office of Science and Technology, established in 1962 by reorganization plan, has the responsibility for reviewing, evaluating and coordinating R. & D. programs conducted by Federal agencies, policy planning for research, making studies of science matters concerning R. & D., and for the financing and administration of such committees as PSAC, FCST, and their panels. It provides for the first time a statutory office in the Offices of the President for these purposes and is also available to the Congress. (Authority for policy planning in science is still retained by the National Science Foundation with special reference to basic research matters.) Its Director is appointed by the President and thus far has been also the special assistant to the President for science and technology.

(*d*) The President's Science Advisory Committee, established by Executive order in 1958 in the Office of the President, is the successor to the Science Advisory Committee established by Executive order in 1950 (administratively under the ODM). It is a part-time Committee appointed by the President to advise him on scientific matters either at his request or on its own initiative. Its Chairman is elected by the Committee and has always been the same individual as the special assistant to the President for science and technology, for which the first appointment was made late in 1957. Its chief functions at the White House level are to consider, review, or study topics, projects,

or programs concerned with R. & D., scientific education and manpower, science information, international science affairs, or other related topics. These are frequently performed by panels set up for the purpose and result in reports, some of which are published.

(*e*) The National Academy of Sciences has the statutory responsibility of providing advisory and consulting services, when asked, for the President, the Federal agencies or the Congress. The NAS was established by act of Congress in 1863 and the act was extended in 1916 to include the National Research Council which provided for the formation of standing and temporary divisions, committees, and panels to assist the NAS in this function. The NAS–NRC is officially regarded as a quasi-Government organization since it has responsibility to the Government but receives no funds in the President's budget. In carrying out its operations under Government request, financing is provided by the component or agency which makes the request. It is, of course, a nonprofit organization.

The NAS is the highest authority on science in the country. Its members are elected from among the scientific community and include a limited number of foreign scientists. In addition to its Government relationships, the National Academy of Sciences has comprehensive programs carried out under its own initiative for the study and planning of research. It holds periodic meetings which include research papers delivered by its members.

In addition, it is the adhering body for the United States in international nongovernmental enterprises such as the International Council of Scientific Unions and its component committees.

(*f*) The role of the White House in the making of science policy may be initiated officially by request of the President, by the Director of the Office of Science and Technology, or by the PSAC in the transmission of recommendations via the Special Assistant for Science and Technology, by the National Science Board via the NSF Director, and also on special matters in response to agency request. At the present time coordination is the responsibility of the Director of the Office of Science and Technology, who is simultaneously special assistant to the President for science and technology, Chairman of the PSAC, and Chairman of the Federal Council for Science and Technology.

Science policy may of course be promulgated in many ways—by presidential announcement, by Executive order, or by presidential endorsement of recommendations by PSAC, FCST, OST, or NSB.

3. What problems are foreseen arising from the domination of mission-oriented research over "free" research?

3. (My discussion of this topic concerned basic research only; presumably applied research supported by an agency is always mission-related.) Chief problems arising from this cause are: limitation of basic research to scientific areas which are judged in advance to underlie developments of existing or potential practical usefulness; e.g., military defense, health, power, agriculture, communications, etc. Generally speaking, mission-related basic research is the variety supported and conducted by industrial research departments and by Government R. & D. laboratories, where the overall purpose is to improve existing products and techniques or to initiate promising useful new ones. This, of course, is an essential part of technology, and

should continue. Obviously it is limited to fields of predicted promise of utility.

As outlined in my address before the American Association for the Advancement of Science,[1] on an approximate basis about 80 percent of the basic research in the country may be regarded as "mission-related" and only 20 percent "free." Hence, mission-related basic research predominates in support by a ration of 4 to 1. The question is one of determining the optimum proportion between the two. One can hardly expect to give the answer in quantitative terms, since there is no ready measure of importance of the results of either except in isolated cases, and in the case of free research the significance of the findings may not be evident for many years.

There is and always will be a strong demand for research, both basic and applied, which is expected to solve important practical problems and to explore regions which may be identified as holding promise for development. No one can quarrel with this thesis. Indeed, many scientists and engineers have in recent years called attention to the great need for this type of activity and there are some who have criticized university research as being too predominantly academic; i.e., "free." This criticism probably stems from the fact that both kinds of research have been increasingly handicapped for lack of funds and with mission-related research, as usual, having an apparent immediate urgency. In my opinion the remedy for this is to review existing developmental projects more critically, to invest in them with more care and thoroughness and in this way to release funds for purposes of research. It is in development where about 70 percent of the R. & D. money is spent. Furthermore, the techniques for this examination and review have been greatly improved by the use of computer facilities, systems analysis, and operations research. Above all, whenever possible, the adoption of crash programs should be avoided as being relatively inefficient and most extravagant in cost.

The chief arguments for free basic research are simple in principle. They are:

(*a*) Mission-related basic research by definition aims at foreseen goals. Free basic research, not having this limitation, offers more opportunity for important and novel discoveries. This asset is borne out by history, since the capital innovative discoveries have generally been made by individuals working on this basis, as witness electromagnetic induction, electromagnetic radio waves, the electron and the laws of electronics, X-rays, radioactivity, relativity, antibiotics, and the laws of evolution. If one tries to argue that the modern situation is different, one should recall the statement made by a leading physicist and believed by many, just before the turn of the century, that the major laws governing the physical world had all been discovered and it remained only to work out the details. As a fitting rejoinder there shortly followed the discovery of X-rays and radioactivity. It is a dangerous thesis to assert that no further capital discoveries can or will be made, and the most likely source is free basic research.

(*b*) The cultivation of free basic research establishes a continually expanding accumulation of basic data on a very wide front, which then becomes available, whenever the need arises, for use in develop-

[1] "The Changing Environment of Science," Science, pp. 13–18, Jan. 1, 1965, vol. 147, No. 3653.

ment and in applied as well as further basic research. This storehouse of available information often obviates the need for new basic or applied research undertaken on a crash basis in developmental projects to remove bottlenecks.

(*c*) Advanced academic training in basic research provides specialists available for future fields of hitherto unforeseen importance.

(*d*) The performance of free basic research is a most important ingredient in the progress of human thought and culture.

It should be added that the encouragement and support of free basic research encounter most fertile soil for its cultivation in the free world and particularly in the United States. In countries with rigidly planned economies this is severely limited if not almost unknown. While in the short haul there is great power in research toward the achievement of foreseen objectives, in the long run limitation to such goals tends to proliferate unwarranted detail, and results in major blind spots as world science progresses into unforeseen territory. The thesis of the undersigned is that the United States is in an advantageous position to make substantial progress in both mission-related and free research.

It is difficult to formulate criteria for the optimum balance between mission-related and free basic research. Insofar as the NSF is concerned, an opinion can be expressed on the optimum extent of support of the free variety. Thus, in the NSF basic research program over the years the proportion of basic research funds granted to applicants has usually varied between 25 and 30 percent of the total funds requested. In view of the quality of the proposals received a more justifiable proportion would appear to be 50 percent. Otherwise the program is spread too thin and too many good projects may go without support. A 50-percent proportion should allow for the requisite selectivity to guard against backing mediocre work.

If the research budget of the NSF could be increased so as to raise its basic research to such a level it would also serve to place the NSF research program in better balance with the basic research funds provided by other agencies. As an approximate estimate, if the basic research money to the NSF were to be increased so as to fund 50 percent of the total amount requested by applicants, then the NSF would be able to furnish about 40 percent of the Federal support of basic research to academic institutions or double its present fraction, without reducing the funds in support of mission-related research.

4. Should the National Science Foundation Act be revised to permit more operational and/or applied research support? (Note that this says "permit" and not "require.")

4. While in principle it might seem a good idea to revise the National Science Foundation Act to permit more operational and/or applied research support and thereby give the National Science Foundation more authority, I do not believe this would be wise unless and until a pressing case arises where this is badly needed. The reason is that, if such authority were permitted, the National Science Foundation would probably be under constant pressure from one direction or another (including from within) to use this power. Direct operational control would tend to develop bureaucratic characteristics, which the National Science Foundation should strictly avoid. Besides, a general entry into applied research would in the long run tend to

bring about relative neglect of the Foundation for basic research. It would change the clientele markedly by bringing in industrial firms and thus expose the NSF to quite strong pressures and to selective support of profitmaking institutions. The present unique position of the NSF in upholding basic research is a strong asset in our Government and among the scientific community. Applied research should be the concern of those Federal agencies which have more specific missions. Furthermore, this division of responsibility encourages the NSF to maintain closer contracts with other agencies for their mutual benefit. It also reduces the area of undesirable competition.

I should favor making no general revision of the National Science Foundation Act to provide this general authority but, if circumstances warrant, assigning special authority to the NSF for a particular, urgent use where no existing agency has authority or competence.

5. How can the National Science Board be made more effective? Should its role be changed? Is new legislation needed?

5. In its present form the National Science Board has the advantage of wide and complete coverage of the scientific interests of the country with respect to geography, scientific disciplines, type of institution and administrative experience. This is possible by the size of the Board and its manner of selection. Administratively it is a large Board for effectiveness in deliberation and disposal of its affairs. This could be remedied by reducing the number, say, to a Board of 15 or 16 members. However, this would limit the aforesaid advantage of representation. A more desirable alternative would be for the Board to delegate more of its authority to its Executive Committee, and its planning to subcommittees or panels of the Broad. The latter alternative is being used more and more. As the size and complexity of the Foundation's operations grow it seems inevitable that the Board should delegate more and more functions to its Executive Committee and/or the Director.

It is here that I believe a change in the National Science Foundation Act might be considered, since the act limits the authority of the Executive Committee.

It should be added that this subject has on several occasions been discussed by the Board. The outcome has always been that its members feel they should all be involved in final determinations essential to policy.

6. Does the fact that members of the National Science Board hold concurrent membership in other Federal bodies providing advice on science policy matters compromise or otherwise influence their independence?

6. Concurrent membership on other Federal bodies is not a serious problem provided membership in other bodies is only on a similar part-time basis and limited to advisory services. It is an asset, in my opinion, to include some overlapping membership of this kind, both in providing broader background for deliberation and in forestalling duplicative discussion or troublesome policy disagreements with another agency. Besides, a strict limitation to independent membership can cause severe restrictions in selection of available members, to the detriment of quality. The latter is a far greater handicap to the effectivenes of such a Board.

7. When the NSF was created in 1950 with a budget limited to $15 million, the National Science Board could, presumably, exercise close supervision over the workings of the Foundation. Since then the budget of the Foundation has increased to about $480 million and the Board has delegated much of its authority to the Director, keeping for itself the authority for major policy decisions. In effect, then, the Board serves as a sort of Board of Governors, and is the only such nonregulatory agency with this form of dual (Board and directory) authority and responsibility. The question arises, is it in the best interest of the country and of science in general to maintain this dual authority; or would it perhaps be better to have the Director solely responsible for the operation of the Foundation, and have the Board serve in an advisory capacity to the Director (a National Science Advisory Board)? In the light of your experience with NSF growth, your comments on the problem are requested.

7. The dual authority existing in the NSF appears to be an outgrowth of the first National Science Foundation Act passed by the Congress which was vetoed by President Truman. That version followed the pattern of the old NACA whose members were appointed by the President and constituted a "governing board" which then selected the Director and the latter reported to them. The President's veto at that time was caused by his belief that this would place the disposal of Federal funds in the hands of a part-time board which would constitute insufficient governmental control. The National Science Foundation Act of 1950 modified this so that the Director was appointed by the President and officially reported to him, while the act limited the authority of the Director in carrying out certain programs without the Board approval. The policy-forming role was retained by the Board. Following Reorganization Plan No. 2, however, the roles of the Board and the Director were more fully coordinated by making the Director a voting member of the Board, instead of a nonvoting member, and by making him Chairman of the Board's Executive Committee.

In the operations of the Foundation this somewhat unprecedented situation has worked well. Conceivably a stalemate could develop or one in which the Board took a determined position contrary to the wishes of the President. The Director would then be in duty bound to back the President's point of view or resign. During my administration no such situation came close to developing. This subject was carefully considered by the Board after a decade of experience and the conclusion reached that the existing setup had worked well and required no change.

Cases calling for prompt action between regular Board meetings may be handled by (*a*) calling special Board meetings (2 weeks' notice) or (*b*) Board delegation of authority to (1) Executive Committee (now in force) (2) the Director. However, under the present act, policy authority cannot be so delegated.

The present arrangement constitutes a safeguard against undue Federal domination or control over scientific activities and enterprises throughout the country. There is at present no body dealing with scientific matters in the executive branch which has comparable experience, stature, and representation, on Government-university relationships, for example. Therefore, in my opinion it is worth continu-

ing as long as no serious difficulty arises. The current arrangement is probably an asset in maintaining good public relations with the scientific community.

If the Board were to be relegated solely to a role advisory to the Director, this would of course strengthen his hand but by demoting the authority of the Board, it would also make membership on the Board less attractive and tend to render the members less attentive to their Federal responsibilities. In my experience with bodies having advisory or responsible functions, a board with assigned responsibility exercises more care and thoroughness in its deliberations and its actions.

8. Please explain in more detail the recommendation in your testimony that NSF should have a contingency fund to exploit breakthroughs in basic research.

(a) Why is a contingency fund needed if scientists are already supported?

(b) Cannot funds be reprogramed?

(c) Are not scientists given enough flexibility in grants to exploit breakthroughs?

8. As partially explained in my testimony a contingency fund for NSF is desirable in order to provide immediate support for a new and promising research discovery or a novel and effective technique of research. As it is, budget plans are made about 2 years in advance of receipt of the corresponding appropriation. These plans are based on the estimated cost of ongoing research, assumed to continue at about the current level, plus the estimated amount required to initiate support of new proposals. Consequently, if during a particular budget year an impressive finding is made which indicates need for extension, there is no money available for the purpose without curtailing funds already planned. This extension may take the form of increasing the staff and equipment already on the project, providing a special research installation for the purpose, or making a series of grants to a number of other research investigators to take up research in the new area. Often this situation is aggravated by the final appropriation being less than the budget requested.

In answer to questions (*a*), (*b*), and (*c*):

(*a*) Contingency funds are needed even though scientists are already supported, since to do justice to important new findings additional funds are required over and above those already provided.

(*b*) Reprograming would mean taking funds from and thus handicapping either ongoing research or new projects of excellent quality or both. Due to the lag in the budget cycle a certain amount of reprograming is always done, of course, but it cannot at present cover the prompt cultivation of unexpected and highly important new discoveries.

(*c*) Scientists are indeed given flexibility in grants to change the character or aim of their research in the light of their findings, upon keeping the NSF informed, but this does not provide additional funds when needed, nor does it permit exploration by others when that appears desirable.

9. Why should not more support be given to nonprofit organizations which are doing anywhere from 20 to 40 percent of their research in fields that are basic?

9. Nonprofit organizations doing basic research may and do apply to NSF for support along with academic institutions. If their proposals stand up successfully in competition they receive grants. This policy is believed to be sound. On the one hand one should bear in mind that such organizations are not ordinarily concerned with education and training, which may be an important consideration in a particular research project. On the other, quite often such an organization may have excellent prospects for full-time team research involving the association of a number of research specialists.

10. We have heard criticism that there has been a tendency, in order to spread research around, to underfund good projects. Do you concur with this point of view?

10. There undoubtedly is a tendency to underfund good projects. In my experience the quality of research proposals coming to the NSF is such that about 50 percent of the total of all funds requested should be granted. This allows a fair margin of selectivity for competitive purposes and to insure quality. Those selected should be financed adequately. But when the above figure is as low as 25 to 30 percent, which has been customary, then a program director is strongly tempted to increase the number of grants by reducing the amount requested by each. If this becomes common knowledge among the grantees, then a quite natural response is to try to anticipate this damaging reduction by increasing the amount requested. When the agency notes this, a most unfortunate situation has developed, destroying confidence on both sides, to the detriment of efficiency and good public relations.

11. We also have heard complaints that NSF has exhibited a tendency to overcontrol its grants through excessive reports and other redtape. Is this a serious problem?

11. The tendency to overcontrol grants through excess reports and other redtape is one which a Federal agency always has to watch, especially in dealing with basic research in academic institutions. This constitutes something of a dilemma since one would wish a basic research scientist to be as free from intereference as possible in his work, while at the same time insuring that necessary regulations are met and that pertinent information is available whenever questions or criticisms may arise. The aim of NSF has been to try to keep the financial and administrative arrangements and reporting within the administrative office of the grantee institution, thus giving the research scientists maximum opportunity for concentrating on their research. Most academic institutions, especially those with graduate schools, have set up administrative offices and thus help to further this procedure. As a rule the responsibility of the research scientist to the NSF is to keep the latter informed about unusual progress or change of aim and to furnish a research report at the conclusion of the grant together with copies of any research papers as they appear. Actually the time of the research scientist in administrative matters is much more likely to be taken up with their local administrators than with the NSF.

Progressive steps have been taken in recent years to simplify accounts and recordkeeping at academic institutions by arranging unified accounts covering for a given institution the existing research grants.

The problem may easily become serious if not closely watched by both parties. As a rule most setbacks in this respect occur as a result of complaints or criticisms which require an investigation and which, rightly or wrongly, result in additional regulations.

12. What conditions have developed in recent years that warrant changes in emphasis as well as expansion of NSF programs?

12. Conditions that have developed in recent years which warrant changes in emphasis as well as expansion of NSF programs are as follows:

The success and continued growth of the so-called project system of research support at academic institutions has led to the initiation of programs designed to compensate for certain difficulties it may cause, especially at universities receiving extensive Federal research support. In the project system, grants or contracts are awarded to an institution for research projects selected by the agency. In the case of NSF and several other agencies this selection is commonly made from among proposals received from individuals or teams of scientists, with the endorsement of their institutions. The selection in a given scientific field is usually made with the advice of experts in that field. In this way the agency and the scientific community cooperate in establishing the support program. Its assets are: best possible guarantee of quality of promise and performance among applicants for support; close cooperative planning between the Federal agency and the scientific community; excellent public relations with the scientists and their organizations. However, since supported projects are selected and financed from outside the institution, project system may bring about the following difficulties for academic institutions which receive considerable support by this method: lack of consideration for the institution itself; lack of flexibility and independence for planning by department and institution heads; possible lack of control on the part of institutional authorities; possible conflict of interest on the part of scientists between a supporting agency and their own university administration.

In the case of agencies with practical missions the project system is justified on the ground that they are primarily interested in research results, and therefore should select for support research relevant to their missions in the most competent hands available, wherever these may be found.

In the case of the NSF, however, consideration may and should be given to the effect of the research support upon the health, strength, and promise of the institution. Accordingly the NSF has established the following programs designed to compensate for these difficulties: institutional base grants; institutional science buildings and research facilities; science development grants.

In its graduate fellowship program, because of preponderant choice by fellows of a few outstanding universities, the NSF has established a supplemental, cooperative fellowship program in which the institution recommends a limited number of fellowship appointments, the awardees to attend the institution, and a training grant program whereby the institution receives funds for graduate research training in a particular area of science.

13. Do you agree with statements of some authors in the recent NAS report on "Basic Research and National Goals" that there is a "deep financial crisis" in the physical sciences?

13. Yes, unquestionably.

That this situation has been cumulative for many years may be observed by noting that the appropriations for NIH (mission-related research) have commonly been higher than those requested in the President's budget, whereas the appropriations for NSF (free basic research in physical and life sciences) have inevitably been less. Correspondingly, the proportion of funds granted to funds requested by applicants has been considerably lower in NSF than NIH. Add to this the fact that in recent years the mission-related agencies which chiefly support the physical sciences, except for NASA, have had gradually to reduce their support of research and the NSF has not had the funds to compensate for this loss of support.

This deficiency in support of the physical sciences became accentuated in fiscal year 1964 when the NSF received and appropriation of only $345 million as compared with $589 million in the President's budget request.

14. The Foundation in recent years has devoted some funds toward improving science teaching as well as curriculum in undergraduate as well as high school levels. Based on this experience, do you believe that fellowship or institutional support of pregraduate education should be proportionately increased or decreased?

14. As to increase or decrease of fellowship or institutional support of pregraduate education, it is my view that the NSF should continue its policy of not establishing undergraduate scholarships (NSF has used this term rather than "fellowships," which is reserved for graduate students and beyond), in the belief that individual undergraduate support is best left as a responsibility of the institution.

General institutional support of pregraduate education would seem more properly to be a responsibility of the U.S. Office of Education in cooperation with State or local organizations rather than of the NSF. In the case of elementary and secondary education, the NSF can provide, as in the past, a most useful service in experimental and pioneering studies and programs directed toward the improvement of science learning and teacher training. If and when successful, the results may be incorporated into the regular educational programs of the Office of Education.

15. What is the explanation for the NSF report in which a shortage of scientists and engineers was projected under the next 10 years, in contrast to the Killian report released about the same time that cited no across-the-board shortage?

15. There have been two NSF reports regarding the projected shortage of scientists and engineers. The first [1] pointed out a current trend which would provide an adequate number by 1970 but only if properly planned and financed. It also reported that not enough scientists and engineers were taking up positions at academic institutions to provide the necessary teaching. The second [2] examined the trend in employment of scientists and engineers with a projection for the next decade. Both based their discussion and conclusions upon a report by the

[1] "Investing in Scientific Progress," 1961.
[2] "Profiles of Manpower in Science and Technology," 1963.

Bureau of Labor Statistics [3] sponsored by the NSF. It is my recollection that the two were in reasonably good agreement; namely, that under adequate planning and financing an adequate number would be trained and employed. Both warned of present serious shortcomings in planning and in funding. A PSAC [4] report was more pessimistic and indicated that we would fall short of training the desired number of engineers and physical scientists.

The Killian report made thorough examination of the utilization of scientists, engineers, and technicians. It concluded that on the whole conditions were healthy in these respects and that indications were that they would continue so.

Except for the PSAC report, there would seem to be reasonable agreement among the three others. All agree, however, that it is of the greatest urgency to provide money, facilities, and trained personnel to do this job, especially since we are already badly in arreas on this point.

16. Are the NSF institutional grants consistent in policy and content with those of National Institutes of Health, NASA, and other Federal agencies? What is the amount of private sector support in these same programs?

16. There are several kinds of NSF grants which may be regarded as institutional. They are as follows:

(*a*) Institutional base grants, which consist of an annual lump sum to the head of the institution amounting to a certain percent, on a sliding scale, of the total NSF research grants made to the institution during the previous year. These grants may be freely used for any scientific purposes; no advance listing is required.

(*b*) Facilities grants, covering on a matching basis (50 percent) construction of laboratory buildings and provision for research installation and equipment.

(*c*) Science development grants, in response to comprehensive proposals from the institution, to defray the costs of research and/or teaching activities according to well-developed plans. This is a highly selective program at present, since it has only been financed in a modest way, beginning about 2 years ago.

(*d*) Training grants are also made to institutions but these generally cover training only in a specific scientific field, at the graduate level.

The institutional grants made by NIH are somewhat similar but originally at least included certain limitations in content and administration not present in the NSF variety. The two programs by NSF and NIH were started at about the same time and were fully discussed policywise between the two agencies.

NASA has a more independent program of institutional grants although it was discussed with NSF before initiation. Its intent was to establish research and training programs at educational institutions concerned with space activities in science and related subjects. These projects were activated upon successful outcome of negotiations with key institutions in different parts of the country, and are subject to possible modification in the light of experience.

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[3] "Scientists, Engineers, and Technicians in the 1960's."

[4] "Meeting Manpower Needs in Science and Technology, No. 1: Graduate Training in Engineering, Mathematics, and the Physical Sciences," the White House, 1962.

In one important instance the Advanced Research Projects Agency has initiated a program of institutional contracts for research on materials. They are liberally financed and likewise were initiated following negotiations with key institutions having high competence in the physical science fields relating to materials and engineering.

The AEC contracts with academic institutions for comprehensive programs relating to atomic energy are well known.

Federal policy and content in these various programs have been discussed by the respective agencies with NSF during the early stages of their development. During the stages of putting plans into operation the coordination has been closest between NIH and NSF, who have had a long history of cooperation.

In line with the new national educational acts the Office of Education is embarking on a variety of institutional grants among educational institutions.

The amount of private sector support is best obtained from NSF.

17. What is known about the size and makeup of that part of the population which has the basic capacity to become scientists or engineers?

(a) Has there been a discernable range of quality in the students which Foundation has supported?

(b) Could more graduate students be supported without compromising quality?

(c) Is the quality cutoff point different in different fields of science and engineering?

17. The question with its subdivisions had best be answered by the NSF which has followed this subject closely over the years and should be able to give up-to-date figures.

18. How does a program achieve the status of a national research program?

18. A program in the NSF achieves the status of a national research program when it follows a unifying subject matter pattern which may be undertaken in similar manner by the participating institutions and when it has been approved by the President and the Congress as such in the NFS budget. Examples are: weather modification, Antarctic research program, International Year of the Quiet Sun.

19. What is the basic objective of the Foundation's weather modification program? Why was this program given to NSF in 1958 rather than to some other Government agency?

19. The basic objective of the Foundation's weather modification program is to stimulate and support basic research underlying the fundamental processes in nature which control such phenomena is climate, precipitation (rain, snow, or hail), thunderstorms, and violent storms such as hurricanes and tornadoes. The authorization includes following current weather modification attempts and research on the subject in other countries. Authority is also included to engage in applied research and initial development to follow up opportunities uncovered in basic research on the subject.

This program was assigned to the NSF in 1958 by amendment to its act after recommendation by the President's Committee on Weather Control, a recommendation accepted by the Director of NSF after endorsement by the interested Federal agencies. The reason

for assignment to NSF was the conclusion by the President's Committee on Weather Control that progress in weather modification awaited a fuller understanding of the natural processes involved, which could only be obtained through basic research. In carrying out this assignment it has been the stated attitude of the NSF that successful developments along the lines of weather modification should be turned over to an appropriate mission-agency such as the U.S. Weather Bureau for implementation.

20. From the standpoint of objectives, program content, and management, which of the NSF's programs do you consider to have been the best; and which the weakest? Based on your experience, what would you say are NSF's notable weaknesses or deficiencies? How may they be corrected?

20. It is difficult to attempt evaluation of NSF programs from the standpoint of objective, program content, and management. Practically all of its programs were planned carefully by the Director and his staff, studied by the Board from the standpoint of the general objective of the Foundation, the advancement of basic research, and education in the sciences, as well as by appraisal of the particular program in question. They were then approved by the President and funded by Congress.

(*a*) It is my opinion that the objectives of NSF programs have consistently been sound and so regarded. Program content has often been subject to modification in the light of experience, after some degree of experimentation—a very health procedure—and the same has occasionally been true of administrative arrangements and management. As to performance, generally speaking, the most effective thoroughly established programs of the NSF and the ones receiving widest approbation from the scientific community have been: the regular programs of grants in support of basic research by the project system; the fellowship programs for graduate students, postgraduates, and science faculty (including teachers); summer institutes for teacher improvement; and science course content studies.

(*b*) More special programs with important objectives that have filled critical research needs and have been well received are: national research centers; certain national research programs—the IGY (in cooperation with the NAS–NRC), the Antarctic research program, oceanography (in particular, provision for basic research vessels and shore bases and in the International Indian Ocean Expedition), the International Year of the Quiet Sun (with NAS–NRC cooperation); research facilities, especially for graduate research, university centers for computing, ecology and atmosphere research; periodic studies and analyses of R. & D. and scientific manpower activities, inside and outside of Government; research and development for more effiective sciense information exchange; and basic research and science manpower policy planning.

(*c*) Programs of high objective importance which have lagged concern NSF participation in basic science affairs and science education in other countries, apart from international programs. Here achievements have been limited by budget restrictions, and by difficulties underlying cooperative arrangements with responsible Federal agencies. Examples are: provision for wider extension of astronomical research facilities in the Southern Hemisphere—a critical bottleneck

for current U.S. astronomical research; NSF technical assistance in Science education among developing countries.

(*d*) On the management side, in the case of the development of a costly research project, it is not at all unusual to encounter difficulties in matching plans with reality and in making steady progress.

In the history of NSF the project receiving by far the most criticism has of course been Mohole. This project, to drill through the earth's crust and sample the mantle, was and is outstanding as to scientific objectives, daring in concept, and of a technical difficulty somewhat comparable with exploration in outer space. Criticism centered around three main aspects: Selection of the contractor; technical procedure advocated by contractor; decisionmaking and supervision of project by NSF. These criticisms were initiated by a certain few individuals who stimulated a large amount of adverse publicity. These were mistaken criticisms, as borne out in review and by further development of the project. The following lessons are to be learned from this episode: (1) When an agency such as the NSF has a special research project of this general character, approved by the President and funded by the Congress, then it must be universally recognized that the agency (NSF) has full authority for decisionmaking—this cannot be assumed by an advisory body, (2) for internal management purposes, the agency should employ a highly capable and experienced liaison officer, on location continuously available to the contractor, and a similarly qualified full-time project officer in the agency responsible for its interests and those of the Government, and for liaison with appropriate advisory committees. In the Mohole case a fully qualified engineer was employed by the NSF in the former position at the outset, but for the latter no qualified scientist was found to be available for several years. In the interim this duty fell upon a staff member who, while well qualified, had responsibility for the entire earth sciences program. This situation came about largely from the continued opposition of the Mohole Advisory Committee, in principle, to such an appointment—a failure to appreciate point (1) above. The Mohole continues to be a most important pioneering project in geology and geophysics and constitutes a real asset to the United States in international science.

(*e*) Progress in the solution of the science information problem has been slow, due to its complexity, the need to develop and find acceptance for novel methods using modern automation techniques, and to the extraordinary rate of growth of the material to be dealt with. Its solution will depend upon the successful outcome of research into the critical phases of the problem, and the evolution of an overall system in which all will cooperate. Because of the skills and experience in many private and public establishments in this activity in the United States, the best solution would appear to be to devise a system suitable for cooperation by all such, rather than to attempt to organize a single comprehensive agency for the purpose as has occasionally been suggested. For the latter the problem is too large and complicated to provide adequate flexibility and efficiency.

(*f*) Progress has also been relatively slow in the field of weather modification. This problem still depends primarily upon basic research to yield better understanding of the natural processes involved. Good progress is being made in the collection of data, by enlarged and

improved global networks with international collaboration, and by the brilliant records of the Tiros satellites. The work has been further handicapped by a critical shortage of scientists trained for research in meteorology. The NSF has aided this situation materially by grants for research and research facilities to qualified colleges and universities which provide a steady increase in output of trained scientists. Another difficulty is the enlistment of others than traditional meteorologists in this research, notably, physicists, chemists, mathematicians, and computer specialists—always a slow process in basic research.

(*g*) A continuing aim in the NSF is the staff recruitment of able scientists, mathematicians, and engineers who have the special qualifications for the type of basic research administration required. This type of science activity is relatively new in Government outside the fields of agriculture and public health, which, however, have comprised mostly applied research. These qualifications are ideally quite stringent—experience and accomplishment in some field of basic research, so as to be known and respected by the scientific community; breadth of scientific viewpoint and appreciation of the attitudes of academic scientists, understanding of university administration (and to some extent that of industrial research laboratories); familiarity with research equipment, its design, construction and use; ability in reviewing research material, conferring with research scientists, clarity of expression in reports and conferences; administrative sense and organizing ability; finally, good personal qualities and skillful participation in the work of the organization. An agency such as the NSF hesitates to try to recruit scientists from among those in the forefront of research in their fields; their current research contributions are undoubtedly more important. The best that can be done is to keep trying for the best qualified individuals and ultimately to retain a fully competent staff. Salary differentials do not now offer the obstacles they once did. The Foundation has had considerable success in securing capable scientists on a 1- or preferably 2-year leave of absence. In this way individuals with outstanding qualifications may be found and hopefully retained. Also the authorization (originally proposed by the NSF) to allow leave of absence from Federal employment, with pay, is an asset in keeping permanent staff members up to date in their fields.

21. When the Foundation first started, it limited itself to granting project grants and fellowships. Now we see it using many more forms of support and, in particular, managing large scientific ventures. Do you think it appropriate for the Foundation to operate research centers? If so, what balance should there be between freedom of research decisions for the scientists and responsibility for effective management and administration by the Foundation?

21. I do not think it appropriate for the Foundation to operate research centers directly, for example as done by NACA (Langley, Ames), and as now continued by NASA. In the case of basic research this leads to unnecessary and undesirable supervision and control. It also entails a stronger and more permanent Federal investment in research facilities with subsequent tendency toward loss of objectivity in NSF planning. It is well adapted to R. & D. laboratories with important Federal missions which do not compete with private enterprise. The most effective arrangement for the operation of research

centers supported by the NSF is the one in current use; namely, by private management under contract with some recognized institution, association, or corporation. The latter is advantageously done by bodies formed for the purpose by the interested scientists or their institutions, as done with Kitt Peak National Observatory or the National Center for Atmospheric Research. In such cases funds and Federal policy guidance are provided by NSF while responsibility and direct supervision come under the governing board which appoints the Director who is responsible for planning and operation. This permits increased flexibility in administration and research while at the same time it provides overall supervision of the contract and funds by the NSF.

22. Considering the signs that research and development funding for many Federal departments and agencies appears to be leveling off to what extent would you think it desirable for the Foundation to sponsor basic research of interest to them? If the NSF were to consider such a role, what effect would it have on the concept of the Foundation as a balance wheel for Federal support of basic research?

22. In view of the apparent leveling off of R. & D. funds among other Federal departments and agencies, it is of course desirable for the Foundation to confer regularly with them concerning their basic research needs and to cooperate in carrying on basic research important to their missions. However, it is my strong conviction that the present policy stated in Executive Order 10521 (1954) should be maintained; namely, that any agency concerned with R. & D. should conduct and/or support basic research in fields closely related to its mission. The key phrase is "closely related"; this requires interpretation. It is evident that up to a point, when R. & D. funds are reduced, the agency may use this definition in a narrow sense and confine its basic research support to highly essential areas. In such cases the Foundation may be able to help by taking on some of the broader areas of basic research which have relevance to the agency's business but which are obviously less essential. This would require an increase in the basic research appropriation for the NSF. But in my opinion it would be a severe drawback, indeed a catastrophe, for an agency to drop basic research entirely since, to be of maximum service, its basic research should be gained at firsthand and not secondhand. Besides, the NSF could never deal adequately with research requirements in special fields vital to an agency mission, such as underwater sound for the Navy, basic chemistry on explosives for Army ordnance or aerodynamics for the Air Force.

23. The subcommittee has heard testimony that research is inseparable from teaching at the graduate level. Does this imply that smaller colleges and universities which cannot mount vigorous research programs inevitably must withdraw from graduate instruction in the sciences? What should the Foundation do?

23. In considering the implications of the statement that research is inseparable from teaching at the graduate level, the major problems is not that of the smaller colleges and universities but rather that of the large institutions. Here the danger is that members of the graduate faculty may tend to take on more and more research at the expense of their teaching classes. The cumulative effect of this is to reduce the undergraduate or even graduate teaching time of the

research faculty. This may even be carried so far that certain graduate faculty members are never seen personally by the students in their classes and the students have no opportunity to hear them discuss their research. Of course, it is almost universal for such faculty members to have graduate students working on thesis problems. This in itself may be regarded as a fine combination of research and teaching although in some cases an active research faculty member may supervise the theses of so many graduate students he has little contact with them.

The problem of smaller colleges and universities is different. Some do not propose to develop graduate schools but prefer to prepare students to go elsewhere for graduate work. This is a legitimate and important role. Such institutions frequently have individual faculty members who are active in research and receive individual grants, especially from the NSF. Many college presidents of such institutions consider this an excellent arrangement. It has the advantage of bringing research into close touch with undergraduate instruction; indeed, it often provides opportunities for undergraduate students to serve as research assistants to faculty members.

The most serious problem arising in this connection is the increasing difficulty on the part of colleges and universities which are relatively less experienced or equipped for research in retaining good research scientists on their faculties. This has always been true to some extent, but within the last decade or so it has become more acute for a number of reasons—the increasing prestige of research, the widening salary differential, the growing use of "team" research and, as always, the importance of association with a number and variety of active researchers.

The Foundation should continue to take steps along the following lines:

(*a*) Increase the number and spread of individual research grants to faculty members of small colleges and universities (in general this requires additional funds so that it may not take place at the expense of important research in highly competent hands at the larger and more active research centers).

(*b*) By suitable selection and distribution of institutional grants, as funds permit, assist smaller institutions in recruiting faculty and facilities having latent capability and promise.

(*c*) Encourage and help to negotiate cooperative arrangements between small academic institutions and large institutions with highly developed graduate schools or in the neighborhood.

Similarly, encourage cooperation among neighboring institutions of similar stature, for the benefit of the group, as, for example, the cooperative arrangements in the North Carolina "Research Triangle" (Duke, North Carolina State, and the University of North Carolina), and among Amherst, Smith, Mount Holyoke, and the University of Massachusetts.

Response by Dr. Dael Wolfle, Executive Director, American Association for the Advancement of Science, to Questions of the Subcommittee on Science, Research, and Development

1. Recommendation No. 4 of your statement to the committee declared that the time has come for the creation of "a new kind of permanent agency or partner in the field of scientific manpower studies"; and you added that the National Science Foundation "is under too much pressure" of other work to do this job properly.

(a) Where do you think the initiative should come from in the move to establish the agency you suggest which would interpret, synthesize, criticize, and improve methodology of scientific manpower studies?

(b) Considering that the present NSF charter seems broad enough to include the activities you suggest for the new permanent agency, what are the advantages of this approach in comparison with strengthening the capability of the Foundation to move deeper into methodological and analytical work?

(c) Doesn't NSF really need to perform this function in order to do its overall job effectively?

1. (*a*) The initiative to establish an agency that would interpret, sythesize, criticize, and improve methodology of scientific manpower studies might come from the Bureau of the Budget, the Office of Science and Technology, or the National Science Foundation. I would suggest the NSF, because it has operating responsibilities and funds that could support the proposal.

(*b*) In response to a question following my testimony on July 1, I said that I did not think it necessary to change the wording of the organic act of NSF. Upon further consideration, it now seems to me that an extension of the wording might be desirable, for, as you suggested, it would provide specific authorization that might aid the Foundation in securing the necessary appropriations.

Nothing in the NSF charter would preclude undertaking or supporting such studies. That they have not done so to a sufficient extent has, I presume, resulted from three countervailing pressures:

(1) Priority has been given to the regular publication of basic statistical series such as "Federal Funds for Research, Development, and Other Scientific Activities" and analyses of the National Register of Scientific and Technical Personnel, and to the tabulation of data requested by congressional committees, the Office of Science and Technology, and other Government agencies.

(2) Personnel ceilings.

(3) Insufficient congressional interest in, or support for, an expansion of this area of Foundation responsibility. (An example was given by Dr. Bowen Dees in his testimony on August 4, when he cited an Appropriation Subcommittee reduction in

the requested budget for scientific manpower and policies studies, and a request that there be a further reduction in the following year.)

"Strengthening the capability of the Foundation to move deeper into methodological and analytical work" will require either additional funds or a curtailment of other Foundation activities.

(*c*) I do not think it essential that these studies be conducted by the NSF staff, although that is one possibility to consider. Whether the reports and analyses are prepared by NSF personnel or by members of an agency outside of NSF, they will be studied by, and will be useful to, staff members of NSF, the Office of Education, the Bureau of Labor Statistics, other Government agencies, and nongovernmental institutions. Some of the studies that should be conducted may be critical of present methods or show deficiencies in present statistical series. Assuming that the people involved are of equal competence, an NSF unit would be as well qualified as an outside body to make objective criticism of Government data-gathering and reporting methods and practices. I suspect, however, that critical reports are more likely to be published promptly, and that they would be more widely useful, if they came from outside one of the agencies being criticized.

It is a matter of judgment whether the methodological and analytical work should be done in NSF or outside. Arguments can be presented to support either decision. I think an outside agency would work more effectively.

2. In this connection, you testified that "no one has really given high priority to the job of collecting, maintaining, and reporting statistical information concerning the Nation's scientific and technical manpower." Do you believe the recent move by NASA (press release of August 5, 1965) to operate, by contract, its new Scientific and Technical Information Facility—which it calls "the world's largest collection of aerospace literature"—will help close this gap?

2. As I understand the NASA press release of August 5, the contract with Documentation, Inc., to operate its Scientific and Technical Information Facility calls for the collection, organization, indexing, and selective distribution of scientific and technical information that will be of value in connection with the exploration of space. This will be useful to NASA but will provide little, if any, information about scientific and technical manpower trends or problems.

3. Would you care to elaborate on your general testimony regarding the desirability of rewording the Organic Act of NSF?

3. See 1(*b*) above.

4. Do you think it might be advisable at least to permit NSF a broader scope in regard to operational projects or applied research in important areas?

4. I would not wish to prohibit NSF from engaging in operational projects or applied research. When the agency was established, more work of that nature was expected than has actually been carried out. Initially, the Foundation was authorized to engage in military research, and one of its first responsibilities was to conclude the Government's rubber research program.

In some areas there is need for a greater amount of applied research, and there is need also, in a number of sectors of the civilian economy, for work on the factors that help determine the usefulness of applied

research and the acceptance of its results. I have in mind some of the codes, regulatory arrangements, and inertia that tend to maintain the status quo instead of inviting innovation.

But some division of labor is necessary among the Federal agencies. The National Science Foundation has been the single Federal agency able to support scientific activities on a substantial scale that does not also have operational responsibilities. Our present policy permits the mission-oriented agencies to support pure or applied research in fields relevant to their missions, and encourages the National Science Foundation to support basic research selected on the criteria of scientific merit and promise, without regard to relevance to any particular missions. This policy seems to me to represent a sound balance. Consequently, although I would not wish to prohibit NSF from engaging to a larger extent in operational projects or applied research, I would recommend that its primary focus and the great bulk of its interest and support not be moved in the applied direction.

5. What about the "teeth or police power" you said is necessary for the effective gathering of manpower data from the various Government agencies? You said that NSF, even though designated as a "focal agency" for this function, can only coordinate agency activities by persuasion and voluntary agreement. Since the data collection function of NSF is so vital as a basis for science policy decisions and for long-range planning, what action do you think is necessary to give the Foundation the increased authority it needs?

5. I did point out that the "focal agency" function of NSF did not involve any "teeth or police power," and in the short run that fact may make it difficult for NSF to secure data or cooperation that it would like to have. However, I would not change the situation. The difficulties and problems that would be created by the assignment of coercive authority would, I fear, be greater than the difficulties of the present system.

6. In your editorial in Science on June 25, 1965, you speculate about possible changes in scope of NSF activities about the application of science. In your opinion, what are the principal arguments for and against such an extension of the Foundation's current responsibilities?

6. See 4 above.

7. You testified that faster reporting of manpower data would be possible with better equipment. Would you elaborate on this statement and perhaps indicate how much more money might be necessary to provide NSF with better equipment? What kind of equipment?

7. I do not know how to answer this question with enough precision to be useful. The equipment needs will depend upon the size and nature of the program, and that is under debate. After those decisions have been made, someone who is more of an expert than I on the capabilities of specific kinds of equipment would be better able to provide this information.

8. You also mentioned the desire for more information as one reason the Foundation is not providing satisfactory statistical services. Is the growth in demand more in information that it would be nice to have but is not essential, or is it in demand for information that is essential to policy and planning decisions concerning research and development?

8. Some of the additional information desired is of the kind that "would be nice to have but is not essential," and some would be of substantial use in policy and planning decisions. The distinction between these two categories depends in part upon the timeliness with which the information is collected and reported. Current information, promptly reported, can be useful in making policy and planning decisions. The same information, reported 2 years later, is of historical value, but no decisions can be based upon it. The type of data that I described as "flow information" would be useful in decisionmaking.

The ways in which manpower information might be analyzed and studied by different agencies and by interested persons outside of Government are varied indeed. NSF and the other responsible agencies will always have to establish priorities and collect only the kinds of data that seem to be of sufficiently general use to justify the costs involved. However, as the agencies gain in knowledge of how to use such information effectively, it is probable that the amount and variety that would be truly useful will increase.

9. The report of the National Manpower Council last July, entitled "Government and Manpower," observed a drastic shift away from preoccupation with numbers of scientific and technical people, to the quality of the required skills of the relatively small numbers of scientists and engineers of exceptional quality who are capable of working in new fields. What responsibility should the Foundation have for developing the methods to collect such information, and to collect and analyze it?

9. There has been a healthy increase in interest in obtaining information about the more highly qualified segment of the scientific and engineering population. No additional authority or responsibility for collecting such information is required. Insofar as educational attainments and records of positions held serve to indicate high quality, the data for scientists are on record in the National Register. The Office of Scientific Personnel of the National Acaedmy of Sciences, with financial support from the National Science Foundation and the National Institutes of Health, has a complete file of all persons who attained the doctorate from American University since 1920. As a part of the operation of the doctoral records file, data are collated from NSF and other graduate fellowship programs and other sources. The amount of information recorded varies substantially from individual to individual, but the basis is already established for a fairly comprehensive file of information about the more highly qualified segment of the population.

10. Advances in science and technology may cause imbalances between demand and supply for scientists and engineers.

(a) To what extent should the Foundation's acquisition and processing of data about money and manpower for research and development be adapted to generate early warning signals of such change? If so, how might this be done?

(b) What is known about the size and makeup of that part of the population which has the basic capability to become scientists or engineers?

(c) Could more graduate students be supported without compromising quality? There was some testimony at the hearings that the the ceiling may already have been reached. Do you think so?

10. (*a*) It will be necessary to do some exploring to learn how the processing of data about money and manpower could generate reliable, early warning signals of prospective imbalances between demand and supply. This certainly should be one of the functions, but the art is not yet well developed.

(*b*) On the basis of school grades, intelligence tests, or similar measures of ability, scientists and engineers are a somewhat heterogeneous group. Practically all come from the top half of the distribution, and in round numbers, approximately three out of four come from the top 15 or 20 percent of the distribution. Whether persons of this level of ability become scientists or engineers or choose to go into other fields of work depends upon interests, educational opportunities, and market conditions. There never seems to be enough men of really top ability in any field, but there is an adequately sized group of young people coming through the elementary and secondary school system to furnish foreseeable needs for scientists or engineers. Cultural, educational, and financial handicaps are more severe constraints than lack of ability.

(*c*) There are very able high school graduates who do not enter college, although their number is much smaller now than it was a decade or two ago. There are high-quality graduate students who do not enter graduate work. We are moving toward a ceiling but we are not there yet. How much more leeway we have varies from field to field. The percentage of recipients of bachelor's degrees in physics who go on to take the doctorate is much higher than the percentage in engineering. There could, therefore, be a greater increase in the number of graduate students in engineering than in physics before we encountered the problem of lowering quality. Another factor that must be considered, however, is the ability of the graduate schools to provide good educational opportunities to larger numbers of students.

11. What studies is the association (or anyone else you know of) now sponsoring to provide more information about the nature and rate of obsolescence for scientific and engineering personnel? Have any effective countermeasures been devised?

11. The AAAS is not sponsoring any studies of the nature and rate of obsolescence for scientific and engineering personnel. I have heard of some such studies, but am not acquainted with them.

One very effective countermeasure has long been in use: direct personal involvement with new knowledge. The man who is actively engaged in research continues to learn. He will not get out of date nearly so rapidly as he otherwise would.

Reading, study, special courses, and a basic education that emphasizes principles rather than current practice are all recognized as useful means of retarding obsolescence. We need more opportunities for persons in midcareer to take time out for systematic refresher courses and to bring themselves up to date. These opportunities are particularly needed by scientists and engineers who are primarily engaged in teaching, design, manufacturing, and in general activities other than research and development.

12. There has been testimony that the best graduate students are frequently unavailable for teaching because the terms of their research fellowship specifically prohibit this activity. Do you believe more research grants should have room for some teaching? Would such flexi-

bility benefit the graduate as well as help in the training of undergraduates?

12. Many Federal fellowships did specifically prohibit the holder from doing any teaching. That prohibition has to a considerable extent been relaxed. Research grant funds can ordinarily not be used to support classroom teaching, although teaching of another and very important kind does go on between the senior and junior members of a research team.

At present, the money to support graduate students comes from several sources and is categorized by function. Money for teaching assistantships comes primarily from university sources; money for research assistantships comes largely from Federal sources, and so does money for fellowships. During their graduate years, it is likely to be useful to almost all graduate students to have two, and in many cases all three, of these kinds of experience. One or two years might be spent as a research assistant, a year or two as a teaching assistant, and the final year on a fellowship, without duties other than to complete his dissertation. Arrangements of this kind could become more general if the university could assign graduate students to teaching assistantships, research assistantships, or fellowships in accordance with their individual stages of development and in terms of what appeared to be most useful for the following year. The universities could have this flexibility, probably with no increased cost to the Government, if the Federal funds that are now granted for fellowships and traineeships, and for research assistantships on project grants, were pooled and given to the universities for the support of graduate students, with the understanding that many of the students would render service in return for their support.

There are administrative difficulties with this proposal, but stating it as a goal indicates the desirability of introducing greater flexibility into the ways in which the graduate departments can use fellowship, traineeship, and research assistantship funds. I believe that the change would benefit graduate students. Whether it would have a noticeable effect on undergraduate instruction is hard to say, but the effect, if there is one, would be more likely to be beneficial than harmful.

RESPONSE BY DR. CHALMERS W. SHERWIN, DEPUTY DIRECTOR, DEFENSE RESEARCH AND ENGINEERING (RESEARCH AND TECHNOLOGY), DEPARTMENT OF DEFENSE, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

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1. Following up your testimony of July 1, what is your view concerning the distinction between mission-oriented basic research, as supported by Department of Defense, and free or undirected basic research, as supported by NSF? What do you believe, as a matter of national policy, the distribution of Federal funds between the two ought to be?

1. Basic research supported by the Department of Defense is in all cases directly or indirectly related to defense needs. No such requirement characterizes NSF-supported basic research. Both types of research are aimed at improved understanding of the workings of nature, and both require selection of highest-quality research investigators, but DOD-supported research has passed through an extra "filter" that imposes the criterion of defense relatedness.

The question of optimum distribution of research effort between DOD and NSF is a difficult one. Rather than reply to it directly, I should prefer to make the comparison with organizations basically more similar to DOD, such as AEC and NASA. These resemble DOD in carrying heavy technological development responsibilities. In my opinion mission-oriented agencies of this kind are the country's largest "consumers" of general research. They have to be, for their future depends on it. The DOD is the largest such agency and should in my opinion be supporting a scientific research program in somewhat the same relative proportion to its total R.D.T. & E. program as the other comparable agencies. This is not at all the case. DOD supports relatively the smallest research program of the three agencies I mentioned, and in basic research supports the smallest program not only in relative but in absolute terms as well.

I believe that research, including basic research, should be supported by the major mission-oriented agencies approximately proportionally to the development load each carries, because of the tendency of today's research to control the effectiveness of tomorrow's development. On this basis either DOD should have a larger research program, or the other mission-oriented agencies should have smaller ones. I believe the former, because all information I have been able to gather to date indicates the multiplication factor of payoff from past DOD research investments to be impressively high, and even the marginal payoff from further investment to be in all probability sufficient to justify it in cost/effectiveness terms. I mentioned in my testimony that we now have in process a study aimed at providing a more quantitative basis for conclusions in this area.

2. How much basic research is DOD currently supporting and what are the DOD plans with respect to the future support of such research and its magnitude in relation to other budget items? Where do you

believe the basic research of principal interest to the DOD should be performed?

2. Following are the basic research levels supported by DOD for the years indicated:

	Obligations
Fiscal year 1964	$259,600,000
Fiscal year 1965	293,000,000
Fiscal year 1966	323,600,000

You will note that the above numbers represent at least a 10-percent increase each year. The current 5-year programing plan for DOD research calls for approximately a 10-percent increase per year. The above numbers may be compared with the current Department of Defense R.D.T. & E. level of approximately $6.5 billion annually.

The basic research of interest to the DOD should be performed partly in-house in our own laboratories. The reasons for this include the need to maintain in-house laboratory quality by attracting talented scientists early in their careers, stimulation of ideas within the laboratory, provision of working-level contacts with the latest developments on the international research front, etc. The numbers of scientists required for these purposes are not large; they represent a very small fraction of the total U.S. scientific community. The remainder of our basic research must necessarily be performed where the bulk of the scientific talent has traditionally resided and still resides—in the Nation's colleges and universities, particularly those having first-quality graduate schools—and in industrial or not-for-profit laboratories. About geographical distribution I shall comment in connection with question 4, below.

3. The point has been made during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. More specifically:

(a) What guidelines or criteria has the Department of Defense established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of DOD's jurisdiction and, therefore, should, or should not, be supported by the Department?

(b) If written criteria have been established by DOD, please submit a copy thereof of the committee.

3. Attached is a copy of DOD Directive 3210.1 and principal references contained therein. This directive provides the only written criteria currently in existence. It will be noted that the criteria are nonspecific, in that they call only for relevance to the "needs" and the "mission" of the Department of Defense. The mission and needs of the Department are in fact so diverse that it would be very difficult to formulate more definitive constraints that would not interfere with proper delegation of authority to the services. I believe that for effective management such delegation is in general necessary in order to bring together authority, responsibility, and specific technical and programmatic knowledge at the critical decisionmaking level.

OCTOBER 26, 1964.

DEPARTMENT OF DEFENSE DIRECTIVE NO. 3210.1

Subject: Administration and support of basic research by the DOD.
References:
(a) Executive Order 10521, as amended, "Administration of Scientific Research by Agencies of the Federal Government."
(b) DOD Directive 3210.2, "Policy on Basic Research Grants and Title to Equipment Purchased Under Grants."
(c) Section XV, Armed Services Procurement Regulation.
(d) DOD Directive 3210.1, "Policy on Basic Research," November 12, 1957 hereby canceled).

I. PURPOSE

This directive states the policy of the Department of Defense on the administration and support of basic research.

II. CANCELLATION

Reference (d) is hereby superseded and canceled.

III. DEFINITION OF BASIC RESEARCH

Basic research is that type of research which is directed toward increase of knowledge in science. It is research where the primary aim of the investigator is a fuller understanding of the subject under study.

IV. BACKGROUND

A. Reference (a) provides broad guidelines for administration of basic scientific research by Federal agencies. These guidelines state that while the National Science Foundation shall be increasingly responsible for providing Federal support for general purpose basic research, the conduct and support by other Federal agencies of basic research in areas which are closely related to their missions is recognized as important and desirable and shall continue.

B. The Director of Defense Research and Engineering is responsible to the Secretary of Defense for the review and direction of the basic research program of the military departments and other agencies of the Department of Defense authorized to conduct or support basic research, and shall insure that this program is executed according to the provisions of reference (a). This review will be of maximum effectiveness if all elements of the Department adhere to the same fundamental principles in their conduct and support of basic research

V. PRINCIPLES

A. Basic research is essential to the development of military power.

B. Continuity is essential to successful basic research. Therefore, long-term planning and funding of basic research will be employed to the maximum possible extent.

C. Basic research may be conducted by competent scientists in universities and nonprofit institutions, industry, military laboratories, or elsewhere.

D. Sustained support of basic research will result in increased effectiveness and economies in military programs.

E. Free and effective communication among scientists is important to basic research.

VI. POLICY

A. It is the policy of the Department of Defense—

1. To conduct and support a broad and continuing basic research program to provide fundamental knowledge, with emphasis on that related to the needs of the Department of Defense; and

2. To assure full utilization of our scientific resources and to extend those resources in those areas of science relevant to the mission of the Department of Defense; and

3. To maintain, through such a program, effective communication among the scientists of the Department of Defense and the scientists of the universities and industry; and

4. To coordinate this program of basic research with the National Science Foundation; and

5. To encourage the support of basic research by other Government and private agencies.

VII. IMPLEMENTATION

A. It is the responsibility of the Director of Defense Research and Engineering to produce, on a continuing basis, a sound basic research program through the coordination and integration of the elements of the program among the military departments and other agencies of the Department of Defense authorized to conduct or support basic research.

B. The Department of Defense provides support of basic research by—

1. *Support of in-house laboratories.*—Basic research in laboratories of the Department of Defense or in laboratories of other Government agencies, best qualified for such work in particular areas, should be encouraged.

2. *Grants to and contracts with educational and nonprofit institutions.*—In situations appropriate for grants under the provisions of reference (b), the grant instrument is the preferred method of supporting basic research by educational and other nonprofit institutions.

3. *Contract with industry.*—Contracts specifically for basic research may be made with industrial contractors (including small businesses) which have a recognized special competence in a given area. In the administration of the provisions of reference (c) which relate to the allowability of a contractor's independent research costs under certain Department of Defense contracts, favorable consideration should be given to independent basic research.

C. The military departments and other agencies of the Department of Defense authorized to conduct or support basic research will provide the Director of Defense Research and Engineering with such information as he may require in order to carry out his responsibilities under this directive, including annual reports through established administrative and fiscal channels of the following, by contract or grant and dollar value:

1. Basic research performed in Government laboratories.
2. Basic research grants to educational and nonprofit institutions.
3. Basic research contracts to educational and nonprofit institutions.
4. Basic research contracts to industrial contractors, including small business.
5. Independent basic research recognized as an allowable cost in an advance agreement under the provisions of reference (c). Such costs shall be reported via the Assistant Secretary of Defense (Installations and Logistics).

D. Within 90 days of the effective date of this directive, two copies of implementing instructions issued by the military departments will be forwarded to the Director of Defense Research and Engineering.

VIII. EFFECTIVE DATE

This directive is effective immediately.

ROBERT S. MCNAMARA,
Secretary of Defense.

[Reprinted from the Federal Register of Friday, Mar. 19, 1954]

MARCH 17, 1954—EXECUTIVE ORDER CONCERNING GOVERNMENT SCIENTIFIC RESEARCH, THE NATIONAL SCIENCE FOUNDATION, AND THE INTERDEPARTMENTAL COMMITTEE FOR SCIENTIFIC RESEARCH AND DEVELOPMENT

TITLE 3—THE PRESIDENT

EXECUTIVE ORDER 10521

ADMINISTRATION OF SCIENTIFIC RESEARCH BY AGENCIES OF THE FEDERAL GOVERNMENT

WHEREAS the security and welfare of the United States depend increasingly upon the advancement of knowledge in the sciences; and

WHEREAS useful applications of science to defense, humanitarian, and other purposes in the Nation require a strong foundation in basic scientific knowledge and trained scientific manpower; and

WHEREAS the administration of Federal scientific research programs affecting institutions of learning must be consistent with the preservation of the strength, vitality, and independence of higher education in the United States; and

WHEREAS, in order to conserve fiscal and manpower resources, it is necessary that Federal scientific research programs be administered with all practicable efficiency and economy; and

WHEREAS the National Science Foundation has been established by law for the purpose, among others, of developing and encouraging the pursuit of an appropriate and effective national policy for the promotion of basic research and education in the sciences:

NOW, THEREFORE, by virtue of the authority vested in me as President of the United States, it is hereby ordered as follows:

SECTION 1. The National Science Foundation (hereinafter referred to as the Foundation) shall from time to time recommend to the President policies for the Federal Government which will strengthen the national scientific effort and furnish guidance toward defining the responsibilities of the Federal Government in the conduct and support of scientific research.

SEC. 2. The Foundation shall continue to make comprehensive studies and recommendations regarding the Nation's scientific research effort and its resources for scientific activities, including facilities and scientific personnel, and its foreseeable scientific needs, with particular attention to the extent of the Federal Government's activities and the resulting effects upon trained scientific personnel. In making such studies, the Foundation shall make full use of existing sources of information and research facilities within the Federal Government.

SEC. 3. The Foundation, in concert with each Federal agency concerned, shall review the scientific research programs and activities of the Federal Government in order, among other purposes, to formulate methods for strengthening the administration of such programs and activities by the responsible agencies, and to study areas of basic research where gaps or undesirable overlapping of support may exist, and shall recommend to the heads of agencies concerning the support given to basic research.

SEC. 4. As now or hereafter authorized or permitted by law, the Foundation shall be increasingly responsible for providing support by the Federal Government for general-purpose basic research through contracts and grants. The conduct and support by other Federal agencies of basic research in areas which are closely related to their missions is recognized as important and desirable, especially in response to current national needs, and shall continue.

SEC. 5. The Foundation, in consultation with educational institutions, the heads of Federal agencies, and the Commissioner of education of the Department of Health, Education, and Welfare, shall study the effects upon educational institutions of Federal policies and administration of contracts and grants for scientific research and development, and shall recommend policies and procedures which will promote the attainment of general national research objectives and realization of the research needs of Federal agencies while safeguarding the strength and independence of the Nation's institutions of learning

SEC. 6. The head of each Federal agency engaged in scientific research shall make certain that effective executive, organizational, and fiscal practices exist to ensure (a) that the Foundation is consulted on policies concerning the support of basic research (b) that approved scientific research programs conducted by the agency are reviewed continuously in order to preserve priorities in research efforts and to adjust programs to meet changing conditions without imposing unnecessary added burdens on budgetary and other resources, (c) that applied research and development shall be undertaken with sufficient consideration of the underlying basic research and such other factors as relative urgency, project costs, and availability of manpower and facilities, and (d) that, subject to considerations of security and applicable law, adequate dissemination shall be made within the Federal Government of reports on the nature and progress of research projects as an aid to the efficiency and economy of the overall Federal scientific research program.

SEC. 7. Federal agencies supporting or engaging in scientific research shall, with the assistance of the Foundation, cooperate in an effort to improve the methods of classification and reporting of scientific research projects and activities, subject to the requirements of security of information.

SEC. 8. To facilitate the efficient use of scientific research equipment and facilities held by Federal agencies:

(a) the head of each such agency engaged in scientific research shall, to the extent practicable, encourage and facilitate the sharing with other Federal agencies of major equipment and facilities;

(b) A Federal agency shall procure new major equipment or facilities for scientific research purposes only after taking suitable steps to ascertain that the need cannot be met adequately from existing inventories or facilities of its own or of other agencies; and

(c) The Interdepartmental Committee on Scientific Research and Development shall take necessary steps to ensure that each Federal agency engaged directly in scientific research is kept informed of selected major equipment and facilities which could serve the needs of more than one agency. Each Federal agency possessing such equipment and facilities shall maintain appropriate records to assist other agencies in arranging for their joint use or exchange.

SEC. 9. The heads of the respective Federal agencies shall make such reports concerning activities within the purview of this order as may be required by the President.

DWIGHT D. EISENHOWER.

THE WHITE HOUSE,
March 17, 1954.

[No. 3210.2, ch. 2 (reprint) June 30, 1964; supersedes ch. 1, Mar. 29, 1963]

DEPARTMENT OF DEFENSE DIRECTIVES SYSTEM TRANSMITTAL

REPRINT OF DOD DIRECTIVE 3210.2, "POLICY ON RESEARCH GRANTS AND TITLE TO EQUIPMENT PURCHASED UNDER GRANTS," NOVEMBER 19, 1962

The attached reprint of DOD directive 3210.2, "Policy on Research Grants and Title to Equipment Purchased under Grants," November 19, 1962, contains the following changes, which are indicated by asterisks:

1. Page 1, in the references: Deletion of former reference (*c*), "DOD Instruction 3210.3, August 29, 1959 (canceled by DOD Transmittal 64–20, June 30, 1964); new reference (*c*) substituted—"DOD Instruction 5100.38, dated March 19, 1963."
2. Page 4, section VII: Deletion of the sentence in parenthesis referring to the canceled reference (*c*)—3210.3
3. Page 5, section VIII: Deletion of subparagraph "D" referring to canceled 3210.3 section XI: Substitution of new paragraph referring to existing military department implementations and amendments thereto.

Implementation.—This amendment is effective immediately. Two copies of implementing instructions shall be forwarded to the Director, Defense Research and development within 60 days.

MAURICE W. ROCHE,
Administrative Secretary.

[Reprint with changes through June 30, 1964]

NOVEMBER 19, 1962.[1]

DEPARTMENT OF DEFENSE DIRECTIVE NO. 3210.3

Subject: Policy on research grants and title to equipment purchased under grants.

References:

(*a*) Public Law 85–934, "An act to authorize the expenditure of funds through grants for support of scientific research and for other purposes," approved September 6, 1958.

(*b*) Public Law 87–577, "Department of Defense Appropriation Act, 1963," section 540.

*(*c*) DOD Instruction 5100.38, "Defense Documenation Center for Scientific and Technical Information (DDC)," March 19, 1963.

(*d*) DOD Instruction 4105.54, "Miscellaneous Procurement Reports," June 20, 1961.

(*e*) DOD Directive 3210.2, subject as above, August 25, 1959 (hereby canceled.)

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[1] First amendment (ch. 2, June 30, 1964).

I. AUTHORITY AND PURPOSE

Pursuant to reference (*a*), this directive—

A. Establishes uniform DOD policy for (1) making grants to institutions of higher education and to nonprofit organizations for the support of scientific research and (2) vesting in such institutions or organizations the title to equipment purchased with grant funds;

B. Delegates authority for carrying out the responsibilities of the Secretary of Defense under reference (*a*).

II. CANCELLATION

Reference (*c*) is hereby superseded and canceled.

III. SCOPE AND APPLICABILITY

This directive applies to Department of Defense components and the military departments which program funds in Program Elements of the Research Aggregation of Program VI, Research and Development, or any other project which meets the defining criteria of the former as stated in section IV.C below. It covers the expenditure of such funds for grants in support of the purposes set forth in section I. The policy for vesting of title to equipment purchased with contract funds is excluded from the scope of the directive and will be subject to the Armed Services Procurement Regulations.

IV. DEFINITIONS

As used herein—

A. "Grant" means an award of funds included in a written agreement executed by a grantor agency of the Department of Defense through its contracting activities under the authority of reference (*a*).

B. "Grantor agency" means a military department or other agency within the Department of Defense that is authorized pursuant to section IX below, to make grants in support of research.

C. "Research" includes all effort directed toward increased knowledge of natural phenomena and environment, efforts directed toward the solution of problems in the physical, biological, and behavioral sciences that have no clear direct military application and address themselves primarily to the expansion of knowledge in these various areas of science.

D. "Educational institution or other nonprofit organization" means any corporation, foundation, trust, or institution operated for educational or primarily scientific purposes, not organized for profit, no part of whose net earnings inures to the profit of any private shareholder or individual.

V. BACKGROUND AND OBJECTIVES

A. The Department of Defense is responsible for assuring that the scientific research necessary to the discharge of its statutory responsibility is given adequate support.

B. Prior to the enactment of Public Law 85–934, the Department of Defense was limited to the use of research contracts in obtaining the services desired of educational or other nonprofit organizations toward this end.

C. The authority to make grants to such organizations for the purpose of conducting research and, as appropriate, to vest title to equipment purchased with grant funds in the institution or organization conducting the research, has increased the flexibility of the Department of Defense in arranging for the conduct of pertinent research.

D. Compliance must be insured with liimtations such as that contained in reference (*b*) which specifies that, "none of the funds provided herein shall be used to pay any recipient of a grant for the conduct of a research project an amount for indirect expenses in connection with such project in excess of 20 percentum of the direct costs," and similar later enactments.

VI. POLICY

A. It is the policy of the Department of Deefnse to employ this discretionary flexibility by selecting either a research contract or a grant for the support of research at an educational or other nonprofit institution on the basis of a de-

termination as to which best furthers the objectives of the Department of Defense.

1. Determination in favor of a grant in lieu of a contract shall be made only after full consideration is given to the nature of the proposed research, as well as the magnitude and extent of the support. In general, grants shall not be made for an initial period of more than 5 years. This determination may depend on but is not restricted to the following factors:

(*a*) *Support of an investigation of broad scope.*—A grant may be more suitable if the grantee is to carry out investigations not profitably confinable to a specific field or particular approach.

(*b*) *Simplicity and economy in execution and administration.*—A grant may be more siutable if there is either no need or no opportunity for detailed supervision by the supporting agency and for periodic progress reports by the investigator. The factor of economy, resulting from the simplification of accounting and auditing procedures, applicable to research contracts, should also be considered but not in competition with substantive factors.

(*c*) *Payment.*—Performance of a task may be advantageously affected by extending to the grantee the greater flexibility of payment which the grant arrangement offers in comparison with the contract.

(*d*) *Multiple sponsorship.*—The grant may be preferable in cases where the Department of Defense intends to support specific portions of the direct costs of a definite research program toward whose support other agencies, authorized to make grants, and nongovernmental groups are also contributing.

2. Title to all or any part of the equipment purchased with research grant funds may be vested in the organization or institution that has conducted or will conduct the research. This vesting of title may be effected in the grant agreement and may be inclusive or specific. Prior to the vesting of title, it must be determined that such actions furthers the objectives of the Department of Defense. This determination may be based on but is not restricted to factors such as these:

(*a*) The retention of title in the Department of Defense creates an administrative burden not warranted by the value of the equipment.

(*b*) The administration and keeping of records by the educational or other nonprofit organization becomes prohibitively complicated or expensive.

(*c*) The expense involved in redistributing or relocating particular equipment exceeds the value of the equipment.

B. Research, development, and evaluation type appropriations of the Department of Defense are available for making grants in accordance with the policy set forth in this directive.

C. The services of the Defense Documentation Center (reference (*c*)) will be available to Department of Defense grantee institutions in the same manner that these services are provided to Department of Defense contractors and according to the same procedures.

VII. GRANT AGREEMENTS

The grant agreement shall be brief in format, containing only those provisions which are required by specific statutes or for the protection of the fundamental interests of the Government. This includes matters such as the limitation of indirect costs to at most 20 percent of the total direct costs; the maintenance of records sufficient to enable a determination that grant funds were expended for the purposes of the grant; the acquisition for the Government, in accordance with the patent and data policies of the Department of Defense set forth in section IX of the Armed Services Procurement Regulation, appropriate rights in inventions and data arising out of the research; and provisions for the revocation of the grant.

VIII. ADMINISTRATION OF GRANTS

A. In fixing the total amount of a grant before it is awarded, the applicable cost principles of parts 2 and 3, as appropriate, of section XV of the armed services procurement regulations will be used as a guide. Appendix C of the regulation will also provide guidance in the handling of property supplies, acquired under a grant, to which the Government retains title.

B. In accordance with reference (b), the indirect cost rate, used for determining grant amounts, shall exceed in equivalence neither 20 percent of the

total direct costs nor the indirect cost rate that has been most recently determined under applicable procedures at the grantee institution for comparable research contracts of the Department of Defense.

C. Except in the case of revocation, grant amounts as determined at the time of award will not be adjusted.

IX. DELEGATION

The authority vested in the Secretary of Defense pursuant to sections 1 and 2 of reference (a) is hereby delegated to the Secretaries of the Army, the Navy, and the Air Force, and to the Director of Defense Research and Engineering for grants of $1 million or less. Grants in excess of this amount will require approval of the Secretary of Defense. This authority may be redelegated to research activities whose responsibilities include the support of research at educational or other nonprofit institutions for grants of $500,000 or less. Grants exceeding $500,000 but of $1 million or less will require approval of the Secretary of the Department concerned or of the Director of Defense Research and Engineering.

X. REPORTING

Reporting pursuant to section 3 of reference (a) will be accomplished in accordance with reference (d).

XI. IMPLEMENTATION

Implementation of this directive will generally be in accordance with the following departmental implementations: Army—AR 70–5, March 6, 1964; Navy—ONR 3900, 10B, March 8, 1963; Air Force—OAR regulation 70–1, April 12, 1963; two copies of all revisions to these implementations shall be forwarded to the D.D.R. & E. within 10 working days after publication.

XII. EFFECTIVE DATE

This directive is effective immediately.

ROSWELL GILPATRIC,
Deputy Secretary of Defense.

4. In response to a question at the hearing, you indicated that DOD frequently awards contracts at times when the technical, administrative, and management criteria between the top several contractors is very close and rather difficult to decide. In such a situation, you said, DOD still does not consider factors of geographical distribution. Please explain DOD's policy in this regard, and why it believes geographical considerations to be totally inappropriate?

4. There was no intention on my part to imply that geographical considerations are totally inappropriate. The question of governmental policy on the geographical distribution of the research funds of mission-oriented agencies in cases in which other considerations are indecisive is of widespread concern in Government. The Federal Council for Science and Technology has under current consideration a definite policy statement applicable to this issue that will provide guidance to all agencies.

5. What is your reaction or response to the Federal Council for Science and Technology interim report for 1963, which states that no usable data were obtained from Federal agencies in an effort to develop projections of agency requirements for funds through 1970?

5. It is my understanding that the FCST report for 1963 did obtain useful projections for research programs out through 1970 when taken on an individual agency basis. Difficulty was experienced, however, when an attempt was made to consolidate these data into an overall projection for the Federal Government. Differences in definitions, categorization, and bases for estimates made it impossible to consoli-

date the individual agencies' data into a common form. Even though most agencies had valid plans, these were formed for their own purposes, not compatible as to format, definitions, time period, etc., with other agency programs. Certain technical areas such as materials and oceanography had well-developed plans. In such instances it has proved possible to project on a functional, scientific area, or commodity basis. Since it is the Government's principal function, however, to meet broad social needs, and since the agencies charged with meeting these needs can do so only by using science and technology as tools. I believe that plans formulated on a mission-oriented basis should always have priority over plans formulated on a technology-oriented basis.

The FCST is well aware of this problem and is currently working toward a compilation of usable data.

6. To what extent does DOD depend upon scientific and engineering manpower information from NSF in program planning and in decisions to undertake new programs? What manpower information does DOD require that it is not now receiving from NSF?

6. Agencies of the DOD keep informed about broad manpower trends through information supplied by the NSF. However, the DOD does not possess any quantitative methodology to deal with scientific manpower utilization and planning problems. To be effective on a national scale such a methodology, if it existed, would have to be used consistently throughout the Federal Government. No adequate theoretical basis for national manpower planning exists, nor have we developed an adequate mechanism of manpower forecasting. Even if a proven theory existed, its implementation in a nonregimented society would present serious difficulties. It is not clear that the problem of optimum national manpower allocation has been solved even in regimented societies.

The DOD would like to receive more complete and up-to-date manpower data from NSF and to see that agency assume, with the firm backing of the Congress, a greater degree of leadership in developing the methodology for understanding and applying data in the manpower field.

7. Is it your view, as a responder to NSF requests for statistical information on research and development, that the guidelines furnished provide for consistency of data submitted by various agencies? How is the preparation of this data monitored to insure its accuracy and completeness?

7. From all past indications, it is believed that the NSF constantly strives to issue guidelines and instructions in such a manner as to insure that the statistical data reviewed by NSF for their various studies and surveys are on a comparable basis. This is, of course, not always possible in every detail but a genuine effort is made in this direction. It must be borne in mind that problems of categorization, particularly in such loosely structured areas of human endeavor as scientific research, are intrinsically very difficult.

The NSF has analysts who work with representatives of each agency before, during, and after each survey is conducted. There is a constant exchange of views and checking of data between the NSF and DOD representatives. Not only is this true at the level of the Office of the Secretary of Defense, but representatives of the Army, Navy,

Air Force, and the defense agencies very frequently participate in the discussions and meetings.

8. How useful is the Science Information Exchange to DOD and to what extent does DOD cooperate with the exchange?

(a) Would you comment on the reasons why only basic research information, up to the present, has been submitted by DOD to the Science Information Exchange?

(b) Do you believe that SIE can potentially supply the research and development project information needed by DOD management in its program planning?

8. There were 73 requests from DOD offices to SIE in fiscal year 1964. The figure for fiscal year 1965, as of March 1965, was 113 requests. Because of SIE's background as a medical and biological sciences information facility, the large majority of DOD users of SIE have been associated with the DOD medical and biological sciences research program.

DOD policy is to cooperate with the Science Information Exchange. There are now on file with SIE approximately 7,000 records representing the fiscal year 1965 basic research program. We expect to bring these records up to date this October, using the computer-based "work-unit" information system inaugurated within DOD last January.

The reason why only basic research information, up to the present, has been submitted by DOD to the Science Information Exchange involves the problem of military security classification. The basic reresearch program is almost entirely unclassified. It reflects and makes available to the general public a balanced picture of the total DOD interest in different areas of basic research. Data covering the details of applied research work are for the most part classified. Making available to SIE only the data on unclassified applied work would present a very misleading picture of the DOD R. & D. program. Even if the individual projects of our applied research program were all unclassified, we should question the advisability of treating as unclassified the entire program in summary form, because of the clear inferences that an analysis of the total applied research would provide regarding future weapon developments.

I do believe that SIE cannot supply all the research and development project information needed by DOD in its management and program planning. The amounts and kinds of information necessary for R. & D. program planning by local management, middle management, and upper management within DOD are very extensive, and include as a part the summary information normally filed by SIE. It would be impractical to file the complete data at a central government point such as SIE. I believe that the alternative method of having each agency keep its own information but with the summary part in a common digital language and format is more practical and more efficient. If the R. & D résumé system is widely implemented, a Government-wide search for any set of related work can easily and quickly be done and the security problem is quite manageable.

9. What studies are DOD or NSF sponsoring to provide more information about the nature and rate of obsolescence for scientific and engineering personnel, and about effective countermeasures? In any event, what has been done to attract older professional people back to school in order to update their technical capabilities? Are we possibly

ignoring or wasting this technical manpower resource? In other words, do we have any program for reeducating older scientists and engineers whose early college training may be obsolete? What suggestions do you have for providing reasonable access to continuing, lifelong education for scientists to prevent obsolescence? In this connection, would future shifts in large Federal technology programs—let us say, away from military R. & D. toward environmental pollution studies—obsolete certain groups of scientists and engineers?

9. No studies are currently being sponsored by the DOD to provide information specifically about obsolescence of scientific and engineering personnel. In this connection I might remark that one of the main interests in my office during the coming year is to determine means of utilizing our in-house laboratory technical and scientific capabilities most effectively and of upgrading our talent, both junior and senior. I have established a small study group to gather data necessary to proceed with this problem.

The Department of Defense emphasizes training and career development of its in-house employees, and encourages similar solicitude for employee career development among defense contractors. A great deal of job "retreading" has taken place in the national economy as a whole, under the stimulus of economic necessity. Government agencies such as NASA and DOD have had considerable experience in this connection during the last decade; e.g., in moving into the new environment of space, etc. It is true, however, that most of the specific devices in effect for furthering advanced education, such as in-house laboratory or company fellowships, are utilized mainly by young people for the completion of their education. Very little is being done to my knowledge specifically to attract older professional people back to school. Were the need for such action strongly felt at local management levels in both Government and industrial laboratories, where greatest familiarity with the problem exists, sufficient authority is considered to reside there to permit local solutions to be sought.

It is my opinion that future shifts in large Federal technology programs, including the one mentioned of environmental pollution studies, are more apt to provide revitalized technical challenges and continuing employment to broadly educated scientists and engineers than to render them obsolete. Very narrowly trained and early overspecialized scientists and engineers may have to pay a penalty for their limited education. But that penalty would probably have to be paid in one way or another in any circumstance, in view of the pace of modern technological change. There is a lesson to be learned here about the importance of starting each scientist and engineer off with a broad foundational education in basic science, prior to specialized training, in order to provide him in later life with the best job insurance he can have—personal adaptability to change.

10. With the advent of the space age the charge has been made that rapid development of space technology has drawn many of the best professors, practicing engineers, and students away from aeronautical engineering into the more intriguing and glamorous field of space engineering, research, and development. Is this true? And if so, is it cause for concern? Is any program in existence or contemplated to assure a balanced input of graduate space scientists and aeronautical engineers into the scientific and technological communities?

10. It is true that many professors and practicing engineers have tended to move away from consideration of the low-speed conventional aircraft toward the very high performance aircraft and missiles or space vehicles. If for no other reason, the more ready availability of jobs and funds in the latter field would cause the transition. This doesn't necessarily mean that the best people have moved nor does it mean that the knowledge requisite for advances in the lower speed vehicles must suffer unduly, although examples of such penalties already experienced can be found.

Many, if not most, of the technologies employed for the design and fabrication of space vehicles are also fundamental to current aircraft. The primary risk I envision is that engineers trained and skilled in the space field, with its premium on peak performance, will have some difficulty at a later date to think in terms of the more prosaic materials, components, and fabrication techniques that are useful and economically desirable for lower performance vehicles, but I believe that a good engineer can overcome this difficulty.

In terms of absolute numbers of people, I suspect that fewer are required for studies and design work of the low-speed conventional aircraft field than is the case in the higher performance area. The economics of the situation, and in the case of DOD, military need, eventually will determine how many individuals will seek each field. Recently increase emphasis in VTOL and STOL aircraft has insured funding for research in the lower speed areas and has attracted competent people. Assurance that the resolution of low-speed aircraft design optimization will take some time to accomplish is probably all that is necessary to insure a flow of people into the technological area.

In the field of aeronautical or astronautical engineering, as I indicated more generally in my answer to the previous question, the secret of success for any technical man is a broadly based scientific and technical education, which permits him to move rapidly in response to the challenge of new problem areas. Well-trained people will be able to move into a new area to a degree determined by how challenging the area is to them and whether the material rewards offered by it justify the move.

11. From the standpoint of objectives, program content and management, which of NSF's programs do you consider to be the best, and which do you consider to be the least useful.

(a) What are NSF's notable weaknesses or deficiencies, from DOD's point of view? How may they be corrected?

(b) In general, what more could the Foundation do to promote the progress of science?

11. I am not in a position to comment on the quality of any specific NSF programs, but I would like to make some general observations regarding the manner in which the NSF can best interact with and support the mission-oriented agencies such as the DOD.

First, I believe that each mission-oriented agency should support on a substantial level basic research which is relevant to its mission. In this manner, the Nation's basic research programs are most efficiently and naturally focused into areas of probable utility to the broad social missions of Government. Furthermore, because of the close coupling between the performer and the potential user, the likelihood of application is enhanced. Also, relevant basic research,

applied research and development are symbiotically related. Together, they form a powerful and indispensable tool for the accomplishment of the agency mission; fragmented and isolated, they become weak and inefficient.

Second, I believe that the NSF should perform the essential function of concentrating on supporting those areas of research which, for any reason or another, are not being adequately supported by the mission-oriented agencies.

Third, the NSF is well suited to taking the lead in building up new centers of excellence which can then compete on the basis of quality for the research dollars of the mission-oriented agencies.

Finally, there are many other functions concerned with the welfare of science, such as technical education, curriculum reform, manpower information, etc., which are best performed by a central agency such as NSF.

As far as I can judge, the NSF and the mission-oriented agencies have, up to the present time, worked together very much in the manner outlined above, and we in DOD would like to continue this way. I believe, however, that increased support to NSF would allow it to better perform its unique functions.

12. Regarding your prototype experiment called Project ILSE, which was mentioned in your statement, are you suggesting that it would be possible for a single group of specialists to analyze all the interagency research in a particular field, and then come up with a balanced program which would be acceptable to all the agencies concerned? How would you go about setting up such a program?

12. Project ILSE demonstrated that it is possible for qualified scientists from more than one Federal agency to review comprehensively the related research programs of each. With proper grouping of topics into disciplinary areas that are relevant to the specialized competences of the reviewing scientists, ILSE experience has established that such scientists can make intelligent decisions regarding duplication of effort, neglected avenues of research, desirable redundancy, etc., if they are provided with accurate abstracts of the research efforts pertinent to their fields.

The basic problem is to organize the available information into relevant and intelligible packages. This can be done easily by competent specialists in "information storage and retrieval" with the help of tapes and computers.

ILSE, in its earliest efforts, was not an overwhelming success, but the experience gained has developed ILSE into a truly workable system, the principles of which can now be applied to other disciplines. For instance, DOD and NASA are doing the same job in materials as we did in ILSE for life sciences. A committee has been set up to assemble and examine the materials projects. Since the dollar magnitudes of ILSE and materials are about the same, we expect to have about the same number of groups of experts examine the 4,000 to 5,000 projects of NASA and DOD and point out overlapping areas and gaps. The first step in any such effort is to be sure we are speaking the same language. Last year NASA and DOD agreed on a common condensed report form. NASA already has the content of these on tape and DOD will have theirs in the next few months.

Having achieved this common language facility and a modern storage retrieval system, we can now compare programs early in the fiscal year before they are too far advanced. In the past people have gone on the assumption that a listing of projects accomplished this purpose, but the resulting summaries were 12 to 18 months old and consequently became only bookshelf items. With rapid information exchange now possible, there is no reason that the same principle cannot be extended to other interagency programs.

13. You also mentioned that DOD provides the logistic support for the Antarctic research program and that DOD scientists participate in the program. Since DOD provides more than three times the amount of funds for this program that NSF does (since 1958, DOD $182 million, NSF $42.6 million) should DOD more properly be the agency to plan and coordinate the program?

13. Despite the difference in relative funding by the DOD and NSF, planning and coordination of the program are more properly accomplished by the NSF. It is the scientists who must control the research program. That agency responsible for the greatest number of scientists should dominate the program planning and coordinating activities. Most of the scientists involved in the program currently are from other than DOD. In view of the fact that the DOD-supported research in science and technology is primarily mission relevant, and in recognition of the limitations imposed by the Antarctic Treaty (copy attached) on the areas of research properly conducted in the Antarctic it is unlikely that any significant shift in the relative proportion of DOD to non-DOD scientists will occur.

The reason for heavy DOD fund commitment in the Antarctic is our unique capacity to provide logistic support. Severe logistic problems imposed by distance and weather are responsible for the high ratio of support costs to direct scientific costs.

By contrast with the case of the Antarctic, we think the DOD should take a leading role in the planning and coordination of research in the Arctic. Knowledge of extremely cold natural environments is highly relevant to the DOD mission, but in the strategically important Arctic, such knowledge can be obtained at far lower logistic cost than elsewhere. Also, the Arctic is an area of great military importance. Arctic research provides an example of a case in which the DOD is actively engaged in research and is taking the lead in both scientific programs and in logistic operations.

Text of Antarctic Treaty

The Governments of Argentina, Australia, Belgium, Chile, the French Republic, Japan, New Zealand, Norway, the Union of South Africa, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America.

Recognizing that it is in the interest of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord;

Acknowledging the substantial contributions to scientific knowledge resulting from international cooperation in scientific investigation in Antarctica;

Convinced that the establishment of a firm foundation for the continuation and development of such cooperation on the basis of freedom of scientific investigation in Antarctica as applied during the International Geophysical Year accords with the interests of science and the progress of all mankind;

Convinced also that a treaty ensuring the use of Antarctica for peaceful purposes only and the continuance of international harmony in Antarctica will further the purposes and principles embodied in the Charter of the United Nations;

Have agreed as follows:

ARTICLE I

1. Antarctica shall be used for peaceful purposes only. There shall be prohibited, inter alia, any measures of a military nature, such as the establishment of military bases and fortifications, the carrying out of military maneuvers, as well as the testing of any type of weapons.

2. The present Treaty shall not prevent the use of military personnel or equipment for scientific research or for any other peaceful purpose.

ARTICLE II

Freedom of scientific investigation in Antarctica and cooperation toward that end, as applied during the International Geophysical Year, shall continue, subject to the provisions of the present Treaty.

ARTICLE IIII

1. In order to promote international cooperation in scientific investigation in Antarctica, as provided for in Article II of the present Treaty, the Contracting Parties agree that, to the greatest extent feasible and practicable:

(a) information regarding plans for scientific programs in Antarctica shall be exchanged to permit maximum economy and efficiency of operations;

(b) scientific personnel shall be exchanged in Antarctica between expeditions and stations;

(c) scientific observations and results from Antarctica shall be exchanged and made freely available.

2. In implementing this Article, every encouragement shall be given to the establishment of cooperative working relations with those Specialized Agencies of the United Nations and other international organizations having a scientific or technical interest in Antarctica.

ARTICLE IV

1. Nothing contained in the present Treaty shall be interpreted as:

(a) a renunciation by any Contracting Party of previously asserted rights of or claims to territorial sovereignty in Antarctica;

(b) a renunciation or diminution by any Contracting Party of any basis of claim to territorial sovereignty in Antarctica which it may have whether as a result of its activities or those of its nationals in Antarctica, or otherwise;

(c) prejudicing the position of any Contracting Party as regards its recognition or non-recognition of any State's right of or claim or basis of claim to territorial sovereignty in Antarctica.

2. No acts or activities taking place while the present Treaty is in force shall constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in Antarctica or create any rights of sovereignty in Antarctica. No new claim, or enlargement of an existing claim, to territorial sovereignty in Antarctica shall be asserted while the present Treaty is in force.

ARTICLE V

1. Any nuclear explosions in Antarctica and the disposal there of radioactive waste material shall be prohibited.

2. In the event of the conclusion of international agreements concerning the use of nuclear energy, including nuclear explosions and the disposal of radioactive waste material, to which all of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article XI are parties, the rules established under such agreements shall apply in Antarctica.

ARTICLE VI

The provisions of the present Treaty shall apply to the area south of 60° South Latitude, including all ice shelves, but nothing in the present Treaty shall prejudice or in any way affect the rights, or the exercise of the rights, of any State under international law with regard to the high seas within that area.

ARTICLE VII

1. In order to promote the objectives and ensure the observance of the provisions of the present Treaty, each Contracting Party whose representatives are entitled to participate in the meetings referred to in Article IX of the Treaty shall have the right to designate observers to carry out any inspection provided for by the present article. Observers shall be nationals of the Contracting Parties which designate them. The names of observers shall be communicated to every other Contracting Party having the right to designate observers, and like notice shall be given of the termination of their appointment.

2. Each observers designated in accordance with the provisions of paragraph 1 of this Article shall have complete freedom of access at any time to any or all areas of Antarctica.

3. All areas of Antarctica, including all stations, installations and equipment within those areas, and all ships and aircraft at points of discharging or embarking cargoes or personnel in Antarctica, shall be open at all times to inspection by any observers designated in accordance with paragraph 1 of this Article.

4. Aerial observation may be carried out at any time over any or all areas of Antarctica by any of the Contracting Parties having the right to designate observances.

5. Each Contracting Party shall, at the time when the present Treaty enters into force for it, inform the other Contracting Parties, and thereafter shall give them notice in advance, of

(a) all expeditions to and within Antarctica, on the part of its ships or nationals, and all expeditions to Antarctica organized in or proceeding from its territory;

(b) all stations in Antarctica occupied by its nationals; and

(c) any military personnel or equipment intended to be introduced by it into Antarctica subject to the conditions prescribed in paragraph 2 of Article I of the present Treaty.

ARTICLE VIII

1. In order to facilitate the exercise of their functions under the present Treaty, and without prejudice to the respective positions of the Contracting Parties relating to jurisdiction over all other persons in Antarctica, observers designated under paragraph 1 of Article VII and scientific personnel exchanged under subparagraph 1(b) of Article III of the Treaty, and members of the staffs accompanying any such persons, shall be subject only to the jurisdiction of the Contracting Party of which they are nationals in respect of all acts or omissions occurring while they are in Antarctica for the purpose of exercising their functions.

2. Without prejudice to the provisions of paragraph 1 of this Article, and pending the adoption of measures in pursuance of subparagraph 1(e) of Article IX, the Contracting Parties concerned in any case of dispute with regard to the exercise of jurisdiction in Antarctica shall immediately consult together with a view to reaching a mutually acceptable solution.

ARTICLE IX

1. Representatives of the Contracting Parties named in the preamble to the present Treaty shall meet at the City of Canberra within two months after the date of entry into force of the Treaty, and thereafter at suitable intervals and places, for the purpose of exchanging information, consulting together on matters of common interest pertaining to Antarctica, and formulating and considering, and recommending to their Governments, measures in furtherance of the principles and objectives of the Treaty, including measures regarding:

(a) use of Antarctica for peaceful purposes only;

(b) facilitation of scientific research in Antarctica;

(c) facilitation of international scientific cooperation in Antarctica;

(d) facilitation of the exercise of the rights of inspection provided for in Article VII of the Treaty;

(e) questions relating to the exercise of jurisdiction in Antarctica.

(f) preservation and conservation of living resources in Antarctica.

2. Each Contracting Party which has become a party of the present Treaty by accession under Article XIII shall be entitled to appoint representatives to participate in the meetings referred to in paragraph 1 of the present Article, during

such time as that Contracting Party demonstrates its interest in Antarctica by conducting substantial scientific research activity there, such as the establishment of a scientific station or the despatch of a scientific expedition.

3. Reports from the observers referred to in Article VII of the present Treaty shall be transmitted to the representatives of the Contracting Parties participating in the meetings referred to in paragraph 1 of the present Article.

4. The measures referred to in paragraph 1 of this Article shall become effective when approved by all the Contracting Parties whose representatives were entitled to participate in the meetings held to consider those measures.

5. Any or all of the rights established in the present Treaty may be exercised as from the date of entry into force of the Treaty whether or not any measures facilitating the exercise of such rights have been proposed, considered or approved as provided in this Article.

ARTICLE X

Each of the Contracting Parties undertakes to exert appropriate efforts, consistent with the Charter of the United Nations, to the end that no one engages in any activity in Antarctica contrary to the principles or purposes of the present Treaty.

ARTICLE XI

1. If any dispute arises between two or more of the Contracting Parties concerning the interpretation or application of the present Treaty, those Contracting Parties shall consult among themselves with a view to having the dispute resolved by negotiation, inquiry, mediation, conciliation, arbitration, judicial settlement or other peaceful means of their own choice.

2. Any dispute of this character not so resolved shall, with the consent, in each case, of all parties to the dispute, be referred to the International Court of Justice for settlement; but failure to reach agreement on reference to the International Court shall not absolve parties to the dispute from the responsibility of continuing to seek to resolve it by any of the various peaceful means referred to in paragraph 1 of this Article.

ARTICLE XII

1. (a) The present Treaty may be modified or amended at any time by unanimous agreement of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX. Any such modification or amendment shall enter into force when the depositary Government has received notice from all such Contracting Parties that they have ratified it.

(b) Such modification or amendment shall thereafter enter into force as to any other Contracting Party when notice of ratification by it has been received by the depositary Government. Any such Contracting Party from which no notice of ratification is received within a period of two years from the date of entry into force of the modification or amendment in accordance with the provisions of subparagraph 1(a) of this Article shall be deemed to have withdrawn from the present Treaty on the date of the expiration of such period.

2. (a) If after the expiration of thirty years from the date of entry into force of the present Treaty, any of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX so requests by a communication addressed to the depositary Government, a Conference of all the Contracting Parties shall be held as soon as practicable to review the operation of the Treaty.

(b) Any modification or amendment to the present Treaty which is approved at such a Conference by a majority of the Contracting Parties there represented, including a majority of those whose representatives are entitled to participate in the meetings provided for under Article IX, shall be communicated by the depositary Government to all the Contracting Parties immediately after the termination of the Conference and shall enter into force in accordance with the provisions of paragraph 1 of the present Article.

(c) If any such modification or amendment has not entered into force in accordance with the provisions of subparagraph 1(a) of this Article within a period of two years after the date of its communication to all the Contracting parties, any Contracting Party may at any time after the expiration of that period give notice to the depositary Government of its withdrawal from the present Treaty; and such withdrawal shall take effect two years after the receipts of the notice by the depositary Government.

ARTICLE XIII

1. The present Treaty shall be subject to ratification by the signatory States. It shall be open for accession by any State which is a Member of the United Nations, or by any other State which may be invited to accede to the Treaty with the consent of all the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX of the Treaty.

2. Ratification of or accession to the present Treaty shall be effected by each State in accordance with its constitutional processes.

3. Instruments of ratification and instruments of accession shall be deposited with the Government of the United States of America, hereby designated as the depositary Government.

4. The depositary Government shall inform all signatory and acceding States of the date of each deposit of an instrument of ratification or accession, and the date of entry into force of the Treaty and of any modification or amendment thereto.

5. Upon the deposit of instruments of ratification by all the signatory States, the present Treaty shall enter into force for those States and for Sates which have deposited instruments of accession. Thereafter the Treaty shall enter into force for any acceding State upon the deposit of its instrument of accession.

6. The present Treaty shall be registered by the depositary Government pursuant to Article 102 of the Charter of the United Nations.

ARTICLE XIV

The present Treaty, done in the English, French, Russian, and Spanish languages, each version being equally authentic, shall be deposited in the archives of the Government of the United States of America, which shall transmit duly certified copies thereof to the Governments of the signatory and acceding States.

IN WITNESS WHEREOF, the undersigned Plenipotentiaries, duly authorized, have signed the present Treaty.

DONE at Washington this first day of December, one thousand nine hundred and fifty-nine.

For Argentina:
ADOLFO SCILINGO
F. BELLO
For Australia:
HOWARD BEALE.
For Belgium:
OBERT DE THIEUSIES
For Chile:
MARCIAL MORA M
E. GAJARDO V
JULIO ESCUDERO.
For the French Republic:
PIERRE CHARPENTIER
For Japan:
KOICHIRO ASAKAI
T. SHIMODA

For New Zealand:
G D L WHITE
For Norway:
PAUL KOHT
For the Union of South Africa:
WENTZEL C. DU PLESSIS.
For the Union of Soviet Socialist Republics:
V. KUZNETSOV [Romanization]
For the United Kingdom of Great Britain and Northern Ireland:
HAROLD CACCIA.
For the United States of America:
HERMAN PHLEGER.
PAUL C. DANIELS

RESPONSE BY DR. GLENN T. SEABORG, CHAIRMAN, U.S. ATOMIC ENERGY COMMISSION TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

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1. In your testimony on July 6 you said, "Research and teaching are closely related."

(a) On the basis of your experience both as a university professor and as a Government administrator, which do you consider more important to the National Science Foundation—the promotion of scientific research or the advancement of science education?

(b) To what extent should holders of NSF graduate fellowships or traineeships be induced or required to do some teaching before they receive their Ph. D's?

1. (*a*) Scientific research promotes scientific education; scientific education is basic to scientific research; in fact the two are indeed inseparable and interdependent. Therefore, regardless of relative funding levels I consider that there is no difference in importance with respect to promoting scientific research or advancing science education.

(*b*) I certainly believe that holders of any and all Federal fellowships should be encouraged to teach as part of their graduate programs, but only a specific university graduate department should require such teaching, not the Federal sponsor. The NSF fellowship literature states that NSF "shares the belief * * * that some experience in teaching contributes to the graduate training process" * * * and permits a fellow "to accept teaching opportunities * * * which will not retard the fellow's graduate training." AEC has similar provisions in its fellowship and traineeship program. Perhaps fellowship administrators could take a more positive approach in encouraging universities to develop appropriate teaching experiences for such fellows, and stress the desirability of this experience in the fellowship literature.

2. What is the anticipated trend within the Atomic Energy Commission concerning its support of basic research? How much of AEC's basic research can be considered to be mission oriented?

2. We expect that our overall research and development efforts will increase over the next decade, especially for basic research in the physical and life sciences. Increased funds will be required for support of new, large, costly experimental facilities and equipment. Such research increasingly depends on the use of more complex, and hence expensive, tools. Concomitantly, decreases in other parts of the AEC budget (e.g., raw materials procurement, production of special nuclear materials) are expected.

Section 31a of the Atomic Energy Act of 1954, as amended, provides for "a program of conducting, assisting, and fostering research and

development in order to encourage maximum scientific and industrial progress;". Further, "The Commission is directed to exercise its powers in such a manner as to insure the continued conduct of research and development and training activities in fields specified below * * * and to assist in the acquisition of an ever-expanding fund of theoretical and practical knowledge in such fields." Clearly, therefore, AEC has broad authority to conduct basic research relating to "nuclear processes * * *, the theory and production of atomic energy * * *, utilization of special nuclear material and radioactive material for medical, biological, agricultural, health, or military purposes; * * *." We thus consider that the conduct of basic research in the specified fields is part of our mission. In addition, we conduct basic research in fields such as oceanography and meteorology to support our applied research, developmental, and production missions. There are, of course, differences in the relationships between certain phases of our basic research mission and our applied research and developmental missions. For example, the results of high energy physics research are, in general, not as immediately applicable to our applied missions as would, for example, be the results of some of our basic metallurgical research. However, on the foregoing premise, we consider that all of our basic research is mission oriented in that it either is part of our basic mission or is necessary to carry out our basic mission.

3. To what extent do you think NSF should sponsor basic research of primary interest to mission-oriented agencies?

3. The mission-oriented agencies draw upon the whole base of scientific knowledge. Because of this and because the interests of the mission-oriented agencies change, I believe the NSF should continue to support meritorious research proposals independent of their current relation to the mission of another agency. On the other hand, the mission-oriented agencies cannot turn over their responsibilities to the NSF. They must continue to give emphasis to those areas of science bearing on their missions, and to exploit pertinent breakthroughs occurring in unrecognized fields, in order to achieve maximum progress. This diversity of support has been one of the main reasons for the strong position of the United States in the field of basic research, in my judgment. Of course, such diverse support requires good coordination among the agencies, which, as I have indicated in the past, does exist.

4. In the light of AEC's extensive experience in financing basic research, is it realistic to call for a 15-percent annual increase in NSF's basic research budget? Where would the undergraduates come from to provide an annual increase in the number of graduate science students? Could graduate schools expand continually without sacrificing quality of facilities, faculty, and education?

4.(*a*) Yes, because a 15-percent funding increase would just barely keep the program abreast of rising costs and anticipated graduate enrollment.

(*b*) College and university enrollments are rapidly increasing, currently at a faster rate than the population increases in the college-age population. The anticipated higher percentages of undergraduates going on for graduate study, as well as the increasing percentages of high school graduates going on to college should require the pro-

jected funding increase in order to provide for the anticipated increase in graduate students.

(*c*) I believe that the existing graduate schools of the country can absorb on an overall basis, a 15-percent annual increase in basic research funds without deleterious effect on the quality of their faculty or their facilities, at least for some time to come. This belief of course presupposes that adequate funds are made available to the institutions for library facilities, for courses and faculty in both the sciences and the arts and humanities, and for all the other vast complex that makes up an institution of higher education. If your question of continuing increase in size is related to any given campus, I suggest that there may be an optimum size beyond which further expansion may very well be deleterious. The above means that the Nation must provide support for increasing numbers of centers of excellence in order to effectively utilize the projected 15-percent annual increase.

5. With respect to science education in general, should more or less effort be expended by the mission-oriented agencies in its support?

5. I believe that mission-oriented agencies should increase their current levels of support for science education. This does not mean the effort should be made at the expense of an agency's specialized mission, but it does mean that the agencies must be very alert in using their resources of money, facilities, and scientific talent for the maximum benefit of science education as contrasted to restricting such "spin off" solely to very narrow specialized disciplines.

6. In supporting science education over the humanities or one field of science more than another, does the Federal Government incur an implied obligation to provide employment in the future for those graduates which it has supported? Do the students incur any implied obligation to stay in the field or to work on federally funded programs?

6. (*a*) There is no direct employment obligation incurred by the Federal Government, nor do I believe there should be. However, the various Federal agencies supporting either broad or narrow educational assistance programs do have an obligation to the taxpayers and to the recipients that the educational program will provide reasonable economic benefits to the recipient and to the Nation. For the individual this is obviously related to employment opportunity. For this reason, I believe that the projected increases in federally supported fellowships must be accompanied by sufficient research funds to provide the meaningful thesis research expecience necessary to assure that the fellow is adequately prepared for future employment opportunities. These opportunities, I am confident, will come because of the very nature of the scientific and technological revolution we are experiencing.

(*b*) Unless the Government is willing to guarantee employment it should not impose specific employment commitment upon the individual recipient. I suggest the best approach for mission-oriented agencies is that currently in use in AEC fellowships which use the language "The fellowships in * * * are limited to the support of those fellows who intend to remain within the field of the followship following completion of tenure." Incidently, though this referenced wording is relatively new in AEC fellowship literature, you may be interested to know that as of October 1964, 84 percent of all individuals who had

previously held AEC fellowships were still within the field of the fellowship. I consider this a phenomenal record.

7. Please explain more fully your statement to the committee that "nuclear reactors on the university campus may be utilized both for teaching and research."

(a) Do you mean simultaneously or separately?

(b) As a practical matter, what proportion of graduate science students at a university that is engaged in basic nuclear engineering research actually contribute to or participate in such research—as distinguished from experimenting with the low-power "teaching reactors" which you described?

(c) Do all professors engaged in nuclear research also teach classes, as you did?

7. (*a*) I mean both simultaneously and separately; with respect to those reactors that are not designed primarily for research purposes, the teaching use will predominate; with respect to those reactors designed for conduct of research, most of the research will be done with use of graduate students, and thus will facilitate both research and education. This demonstrates once again that graduate education and research are inseparable.

(*b*) A recent survey of university reactor utilization indicated the following: (1) Reactors of less than 10 kilowatts, frequently referred to somewhat erroneously as "teaching reactors" have been used for less than 25 percent of their operating time in research; (2) reactors of power levels up through and including 100 kilowatts are used equally for research and "teaching"; (3) "research reactors," those with power levels significantly higher than 100 kilowatts, have approximately 85 percent of their operating time devoted to research.

(NOTE.—Research utilization as shown above includes thesis research by graduate students, an example of truly "educational" reactor use.)

Statistics are not available as to numbers of students actually using reactors in laboratory courses versus those using them for research. Even in the case of 85 percent utilization for research, it is entirely possible that more individual students participate in the laboratory course use than in the research use, since research is usually an individual operation whereas courses involve a number of students.

(*c*) No. However, I believe that essentially all university faculty should perform both teaching and research duties.

8. To what degree do scientists and engineers drift away from their professional vocations into other fields—such as management, trade or commerce, finance or other business? Is this good or bad? What can be done to improve career counseling? At what educational level?

8. (*a*) University graduates in all fields do often leave the relatively narrow confines of their particular specialty, moving into a wide variety of positions which have some relationship to their own training. I have heard that approximately 50 percent of all engineering graduates do not become professional engineers; and in recent years the fields of management and sales increasingly have recruited engineers, and to some extent scientists, because of their special training.

(*b*) Widespread utilization of scientific and engineering talent in fields other than their own specialty is good for the Nation. The organizations for whom they work, as well as the individuals themselves, benefit from broadened views which lead to new insights and approaches to problems affecting business, education, and government.

51-204—65—vol. II——22

(*c*) I believe that career counseling must be strengthened at both the secondary school and the college level in order that each individual may be adequately advised as to the various educational paths that will enable him (or her) to make the greatest use of his own intellectual capabilities. The U.S. Office of Education has sponsored summer programs for secondary school counselors; I suggest this be expanded. College faculty, especially at the undergraduate level, should also be involved to a greater extent in guiding students toward the broadest possible education as well as toward an appropriate degree of specialization. I would warn against concentrating upon the sciences; adequate attention should also be paid to all academic disciplines, to careers in teaching, in government, in social work in the broadest sense.

9. You suggested that NSF step up support for additional educational opportunities for both students and teachers. How much should NSF's programs be boosted in this regard?

9. I do not recall any specific comment I made regarding increased financial support for students and teachers, as distinct from a general concept of increased financial support for the entire gamut of NSF science education and research support programs. We do not have the detailed familiarity with specific NSF programs to give a categorical answer in terms of funding level for any particular item.

However, I would suggest a significant increase in the efforts to involve undergraduate students and faculty, especially from the smaller colleges, in ongoing research activities of the Nation's universities, and of Federal facilities. I would increase the number of working conferences in which college and university faculty can explore the significance of scientific and technological development upon science curriculums in higher education, and can design new curriculums.

10. Are you satisfied with the ratio of NSF funding in regard to project grants versus institutional grants?

10. I do not have enough detailed data on which to formulate an opinion on the very specific question posed. However, as stated in my prepared testimony, I believe NSF should receive additional funds for support of the highest quality research (project grants), for support of research at less well-known institutions (presumably through project grants) and for the institutional base grants and science development grants programs. The institutional grant programs require additional funds in order to develop additional centers of excellence, to increase the Nation's output of scientifically trained people and to permit the institutions reasonable flexibility in the use of funds. Project grant support requires further increase to allow the Nation to support those capable of conducting good research, to add to our fund of basic knowledge and to assist in the training of graduate students. A more rapid increase in the institutional grant program support is desirable but will also require a more rapid rate of increase for project grant support at the time the institutional grant recipients are ready to submit (additional) requests for project grant support. Under no circumstances should increased funds for institutional grants be provided at the expense of project grant support.

11. The AEC plans to support 372 predoctoral fellows in fiscal year 1966, contrasted with 8,040 by NSF, 3,646 by NASA, and 4,000

by NIH. In view of the relatively small number supported by AEC, should this program be absorbed by NSF?

11. (*a*) I believe that numbers alone are never the sole measure of the need to support separate mission efforts.

(*b*) I strongly believe that the AEC must continue its separate fellowship and traineeship activities. Our traineeships emphasize nuclear engineering and are available at campuses where we have very close and continuing contacts. The AEC special fellowships in health physics require fellows to spend 3 months at an AEC laboratory site gaining actual experience in utilizing their education. The AEC laboratory graduate fellowships provide opportunities for M.S. and Ph. D. thesis work using very specialized facilities under the guidance of the specialized scientific staff members of AEC contractors. I believe these special features justify continued AEC administration despite, or perhaps because of, the relatively small proportion of total Federal fellowships involved. I suggest that it is illogical to expect NSF adequately to administer these specialized activities which use AEC facilities and staff.

12. In your book, "Education and the Atom," you describe how the Florida State University, the Public Health Service, and the AEC worked together to establish a new center of excellence in molecular biology at Tallahassee. This was in 1959, before the Foundation began its science development program. Do you see future possibilities for similar interagency collaboration? What should be the role of the Foundation concerning such ventures?

12. Yes; there are many possibilities for more interagency collaboration. This is especially true for mission-oriented agencies which may have overlapping interests such as the U.S. Public Health Service and the Atomic Energy Commission. These agencies are already developing programs of joint interest in the fields of radiation carcinogenesis and centrifuge development at the Oak Ridge National Laboratory. Since the NSF has the broad field of basic science as its concern, there is overlap of interest with several mission-oriented agencies. However, the NSF is not an operating agency and does not normally have specific requirements to meet that on occasion might better be developed in concert with another agency. In the future, however, such requirements may very well develop.

Another example of interagency collaboration in the development of centers of excellence is the interdisciplinary materials research program which is just now reaching fruition. In this case the agencies working together through the Federal Council for Science and Technology developed a plan to assist universities to build new laboratories, acquire modern expensive equipment, develop central service facilities, and expand their graduate research programs for the purpose of increasing the production rate of trained manpower in the materials-related sciences. Several of these new laboratories will go into operation this year. In most instances, all of the agencies support individual projects within the complex, each of which is able to proceed more efficiently because of the "core" facilities provided by the sponsoring agency.

I foresee the possibility of many such collaborative efforts in the future. Generally speaking, the mission-oriented agencies support research where there is demonstrated capability and the research can be

judged a mission-related. This is largely true, although not completely, of AEC, even though we have a basic research mission in specified fields, as explained in the answer to question 2. Therefore, the aid in development of the initial capability and the support to attract the initial cadre of scientists usually is more properly the role of the NSF rather than the mission-oriented agency.

It is clear that joint efforts by NSF and other agencies working in concert could do much to speed up the development of new centers of excellence, perhaps by NSF providing grants for initiation of building programs and furnishing basic equipment while other agencies support continuing programs in the same institutions in the areas of their responsibility.

13. With respect to the future utilization of AEC laboratories, do you foresee that they will continue to be fully utilized with the atomic energy program? Might your special facilities and equipment be used for other basic research? If so, what would be the appropriate role for NSF in arranging for such use?

13. We believe that our laboratories can be fully utilized within the atomic energy program for many, many years. They are fully occupied now; and there are many tasks to be undertaken should specific activities now being carried on diminish in importance or requirement. However, this does not mean that our special facilities and equipment cannot be used for other basic research. In fact, they are. An appreciable amount of research is conducted for other agencies at the AEC laboratories, some of it in nuclear fields, some of it nonnuclear, and some of it on a cooperative basis such as the cocarcinogenesis program at ORNL. This is jointly sponsored by AEC and NIH.

We will continue to make available to other agencies our specialized facilities and capabilities to the fullest extent possible, consistent with the satisfaction of AEC needs and the lack of availability of equivalent services in the private economy. Because mechanisms for arranging for their use are already available, we see no special overriding role for NSF for this purpose. We would participate with NSF in arranging for such use where mutual interest and advantage exists. Of course, individual facilities at any of our laboratories can become surplus to the specific mission for which they were originally intended. In these cases, AEC would gladly make them available to other Federal agencies, or to colleges and universities, and would welcome their use by such parties, assuming appropriate financial arrangements can be made.

14. Do the major AEC laboratories, such as Argonne and Brookhaven, serve as national resources in the same sense as the NSF national research centers through their availability to qualified scientists without regard to organizational affiliation? What is the AEC policy with respect to visiting scientists at its laboratories? What is the precentage of time that facilities can be used for research by such scientists?

14. Yes, the major AEC laboratories serve very much as a national resource, particularly in the basic research area, and are made available to qualified scientists without regard to their affiliation. Of course, we want to assure that they are used primarily for the purpose for which they were established; namely, research and development in the nuclear fields; and in these fields we want to assure that sci-

entific merit governs their availability. This is particularly true of our high-energy physics facilities, although the concept does not stop there.

For example, each of the major laboratories has a variety of programs wherein specialized facilities are made available to scientists from other organizations on a collaborative or a guest basis. In these cases, qualified scientists may join the laboratory staff on a salaried or nonsalaried status, depending upon the particular situation, for periods of a year or more, or they may make intermittent use of specific facilities for individual experiments.

Examples of other programs include (*a*) summer participation programs wherein university professors, and in some cases high school teachers, come to the laboratories to participate in ongoing research projects (*b*) graduate student fellowship programs where the student carries out his thesis research at one of our laboratories after completing the other requirements for his degree; (*c*) traveling lecture programs where at our expense our scientists travel to participating universities to deliver lectures and conduct symposia. Such programs were initiated many years ago at some of our multiprogram laboratories but have now been extended to other AEC installations such as the National Reactor Testing Station in Idaho, the Pacific Northwest Laboratory in Richland, Wash., and the Savannah River Laboratory in Aiken, S.C. We are encouraging these installations to expand their cooperation with nearby university faculty and their students in providing opportunities for research and training which are mutually beneficial to the AEC and to the educational institutions, their faculty, and students.

From these few examples it is clear that our facilities are used for both research and educational purposes, and that our major laboratories are indeed national resources. Rather than speak about the percentage utilization of a laboratory as a whole by outsiders, it is perhaps more meaningful to think about individual facilities. Even so, I can state that at the present time the scientific staff of the Brookhaven National Laboratory is composed of almost equal numbers of permanent employees and of visitors. Obviously this is an unusual case and the overall percentage utilization by outsiders at our other laboratories is substantially lower.

Our high-energy physics installations find a high degree of utilization by "users groups" not directly connected with the prime installation. It is interesting to note that the high-energy physics facilities at Brookhaven are utilized at the present time to the extent of 70 percent by outsiders. Argonne Naional Laboratory has a collaborative arrangement with the midwestern university community to make available its neutron diffraction facilities to outside users up to 25 percent of the time—specific requests being reviewed by a board of experts composed of laboratory and university scientists. I could cite many more examples referring to our reactors, low-temperature facilities, engineering facilities, and other high-energy physics facilities, to name a few.

15. In your prepared statement, you said that the AEC finances proposals for research only on the basis of scientific merit. Previous testimony revealed that the Department of Defense frequently awards research contracts on proposals in which the technical, administrative,

and management criteria between several contractors are very close and difficult to decide.

(*a*) *Is this true also in AEC's selection of contractors? If not, what criteria does AEC use in order to make the selection between the top several contractors strictly on merit, and how do they differ from DOD's criteria?*

(*b*) *If a selection between the top several contractors is difficult to make, do you consider geographic consideration to be appropriate? If inappropriate, why?*

(*c*) *Has AEC utilized geographic consideration in the past in selecting research contractors, or does it plan to do so in the future?*

15. (*a*) The overriding consideration in the award of contracts for research is the scientific merit of the proposed work coupled with the capabilities of the principal investigator(s) and the facilities available to him. In the award of contracts for development activities involving hardware development, construction of facilities, close integration with work at other contractor sites, etc. (such work constitutes the large fraction of DOD activities) and in the award of contracts for operating major Government-owned facilities, the administrative and managerial capabilities of the proposer are important factors to be considered in the award of a contract. Generally, for the same type of effort, AEC and DOD criteria are similar—all the factors which have a bearing on which organization can best perform the job in question are considered and carefully weighed in arriving at a decision.

(*b*) We consider that we have a good geographic spread in the location of our basic research contracts with universities and in the location of our Government-owned laboratories and research centers. We do feel that it is highly desirable to maintain AEC's existing major laboratories and plants as strong centers to carry out AEC's mission and, as such, utilize their facilities and highly capable personnel to perform a significant fraction of the AEC's R. & D. activities.

However, with respect to selection of research and development contracts for work in commercial facilities, AEC has the following policy, published in atomic energy procurement regulations 9–56.404: "In selecting recipients of research and development work, it is basic AEC policy to assign the work where it can be done most efficiently and effectively. Where it is otherwise appropriate to assign the work to a commercial concern, it is also the policy of the AEC to make such wide distribution of contract awards as will encourage broad participation by qualified research and development contractors performing work in their own facilities in order to (*a*) maintain a competitive industrial base; and (*b*) prevent firms from attaining a predominant position in a major segment of the atomic energy industry."

We have no specific policy statements on the matter of geographical considerations in the award of contracts, beyond the one cited above. Although geographical distribution as such is not a primary consideration in awarding AEC research and development contracts, we clearly recognize the significance such awards can have for certain regions. As a result, one of our objectives has been to bring about a more widespread participation in the atomic energy program although our main objective always is to accomplish best whatever particular task must be performed. When these two objectives are incompatible, the former must of necessity give way to the latter.

Therefore, I am inclined to answer your specific question by saying that if other things truly are relatively equal among several top contractors and the choice is therefore difficult to make, geographic consideration would be one factor that could appropriately be applied. My concern is that other things are too infrequently, if ever, relatively equal. Thus, a strong policy along the lines indicated could lead to the undesirable substitution of political geographical judgments for objective standards of excellence in the apportionment of research and development funds.

(c) Through natural processes we believe that we have attained a reasonable geographic distribution of our research contracts. We have no plans specifically to utilize geographic considerations in the selection of research contractors beyond the application of the policy statement quoted above.

16. As a former member of the National Science Foundation Board, how would you compare it with the Atomic Energy Commission with respect to its authority, functions, responsibilities, and agency operations?

16. The National Science Board, consisting of 24 members, is the policymaking body of the NSF, and meets approximately 9 times a year. The Board must either approve, or delegate authority to its Executive Committee or to the Director to approve fellowships and grants or contracts for basic scientific research activities. The Board is clearly not a day-to-day operating body. The main activities of the NSF are the support of basic research in the physical sciences, engineering, mathematics, biological, medical, and social sciences; funding education in these sciences and fostering interchange of scientific information; providing a clearinghouse of information on U.S. scientific and technical personnel; and development of studies related to planning of national science policy.

The Atomic Energy Commission, in addition to conducting basic research programs and education and training activities, and fostering scientific information interchange, is responsible for raw materials procurement and processing, a large effort on the production of special nuclear materials, the development and manufacture of nuclear weapons to meet all military requirements, and the development of applications and utilization of atomic energy, for electric power, propulsion, space exploration, and industrial, research, medical, and other purposes. The Commission is also responsible for regulating private possession and use of reactors and nuclear materials in the United States.

The responsibility for all these activities rests with the five Commissioners. They serve full time and are responsible for policymaking and for oversight of the day-to-day activities of the agency.

17. What is the AEC's response to the Federal Council for Science and Technology interim report for 1963, which states that no usable data were obtained from Federal agencies in an effort to develop projections of agency requirements for funds through 1970?

17. The data submitted by the Atomic Energy Commission and used in connection with the preparation of the Federal Council's interim report for 1963 were derived from our internal planning documents. Such data have been most useful for internal management purposes including the longer range formulation of the Commission's research and development programs and the preparation of budgets, and budget

projections. The data furnished also were fully responsive to the request made by the Federal Council and we believe that the Council's Long Range Planning Committee considered the AEC's response to be a competent submission.

The Federal Council report stated that "this effort did not result in usable data . . . ." This finding is related to the question of whether consolidation of individual agency plans for a relatively short period—10 years, 1961 to 1970—is an adequate or even valid base for developing broad national goals for research and development.

The Federal Council has found that the concept of Government-wide long-range planning is complex and much more work will have to be done before the problems, including those revealed in the initial study, are resolved. The data furnished by the agencies helped in identifying the scope and nature of the problem, and to that extent may have been useful and well worth the effort.

18. Exactly how does the AEC make use of the Science Information Exchange?

18. The Science Information Exchange provides information which is an integral and routine part of the AEC's procedure for evaluating and processing research proposals. When a proposal is processed, information is provided by SIE on the support the investigator receives from all Federal sources reporting to the Exchange. This material covers past support, present support and insofar as possible gives the amount for pending proposals in the name of the investigator and his principal assistants whose names appear on the proposal.

When support is granted the investigator provides an abstract of his contemplated work to SIE. This is the source of information which then becomes available to other Federal agencies that make use of the Exchange.

The Exchange can by use of these abstracts provide answers to questions concerning the extent of research being supported in various areas of science. The AEC research administrators make frequent use of this capability to insure that unnecessary duplication of effort is avoided and to insure that an area basic to AEC's responsibilities is not being neglected.

19. The point has been brought out during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. More specifically:

> *(a) What guidelines or criteria has the AEC established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the agency's jurisdiction and, therefore, should, or should not, be supported by the agency?*
>
> *(b) If written criteria have been established by AEC, please submit a copy thereof to the committee.*

19. (a) The budget categories and the statements of functions and delegations of the various divisions of the AEC detail the areas of research which are appropriate for support by the AEC. These in turn are based on section 31 of the Atomic Energy Act, to which I referred in the answer to question 2. In addition, the many years of experience by AEC in conducting its research gives us a competent and

sophisticated scientific staff that really has no trouble in arriving at appropriate judgments with respect to suitability of a proposal for AEC support.

Upon receipt of a proposal from a university, the appropriate AEC scientist or engineer reviews the subject matter of the proposal in the light of these guidelines. If it is found to be outside the purview of the AEC, it is suggested to the proposer that he seek support from a more appropriate agency. As is more often the case, if the proposal has been submitted to several agencies, two or more may find the research of interest to them. In these instances, the research administrators, after carrying out their individual evaluations, discuss the proposal in terms of relative interest in each of the agencies and the capability by each agency to support the proposal, as well as other administrative matters. At these informal discussions, a decision is reached as to which agency will provide the requested support.

As I stated in my testimony before this committee on July 6 we have not had an unresolved jurisdictional problem. It is a fact that we have many more requests for support of meritorious research than we are able to satisfy, and as a consequence, it is never a matter of dispute as to which agency will take the responsibility, rather it is a matter of sharing the overall responsibility and seeing that the most worthy proposals receive support.

(*b*) We do not really have written criteria covering specifically the question raised. We do have budget categories, as well as functional statements, covering the activities of our scientific divisions. However, it is my impression that this sort of material is not what you really want. If you do want this material, we can readily give it to you.

20. In your speeches in recent years, you have called attention to problems of technological obsolescence of manpower. What future role do you see for the Foundation in studying and sponsoring means to retrain and reeducate scientists and engineers to extend their useful work life? What effect would this have on supply of scientists and engineers for new work?

20. The need for continuing education as well as reeducation is increasing every year, due to our changing society in general and to our rapid scientific and technological development in particular.

(*a*) It should be noted that the wide variety of NSF programs for helping to create better teachers through faculty institutes, conferences, and faculty fellowships are a combination of continuing education and retraining for scientists and engineers whose major responsibilities are teaching and research. Thus NSF already does have an active role in retraining and reeducation so that individuals may have greater capabilities for a useful work life.

(*b*) I suggest that NSF should broaden the foregoing activities to examine the current needs for continuing education and retraining of engineers, scientists, and technicians, and to examine the many current innovations being adopted by some segments of industry, by those conducting adult education, and by the foundations working with specific universities. Such an overall study is now overdue, and I believe NSF is in the best position to make this broad overview. As a result of the study, I would anticipate that NSF might find it advisable to sponsor conferences and institutes for individuals from the universities, from

industry and from Government to design a variety of programs that might then be incorporated in the Nation's total educational system. Funding of regional continuing education centers might be an appropriate function of NSF in addition to those private foundations already working on such studies.

Such a program should include cooperative programs with the Department of Health, Education, and Welfare, the Department of Labor, the Office of Science and Technology and the State educational systems that sponsor community college programs. The specialized agencies can also help; for example, the entire atomic energy program required a great deal of retraining of manpower, especially in the earlier days.

21. From the standpoint of objectives, program content and management, which of NSF's programs do you consider to be the best, and which do you consider to be the poorest?

(a) What are NSF's notable weaknesses or deficiencies, and how may they be corrected?

(b) What additional objectives or programs do you think the Foundation might undertake to promote the advancement of science?

21. (*a*) NSF's principal weaknesses and deficiencies stem from a lack of sufficient funds to support their objectives and responsibilities. Limitations on time and manpower at the AEC as well as lack of detailed knowledge of NSF activities do not permit a detailed balanced review of all of the functions and activities of the NSF. Thus, I believe it inappropriate to make a statement on which is best and which is the poorest or to attempt to point out notable weaknesses.

I do wish to make another point, which, however, should not be considered a criticism—rather an observation. It must be recognized that there are certain types of projects which the National Science Foundation may not be adequately equipped to handle at the present time. Of course I am referring to the very large projects such as that exemplified by the 200 Bev. high-energy particle accelerator. To manage programs of this sort properly, an agency must have experience and depth in construction, procurement, practical engineering, legal, and fiscal matters.

The AEC inherited an extensive management capability from the Manhattan Engineer District and thus at its inception was equipped to handle very large projects. The National Science Foundation in its short span of life has developed managerial and scientific capability in a praiseworthy fashion. If the National Science Foundation is expected to have the capability for all programs that might come within its charter of responsibility, it should be provided with additional inhouse technical and administrative capability.

(*b*) I do suggest that in the whole area of education, not merely science education, the Federal Government, especially the National Science Foundation and the U.S. Office of Education, should take a more positive stand of leadership to correct the many educational deficiencies that were so well pointed out during the White House Conference on Education.

I specifically suggest that NSF along with the Office of Education develop a coordinated approach to secondary school science curriculums, avoiding the current emphasis on specific science courses.

A more active program is needed to alter collegiate undergraduate science and math curriculums to reflect the changes already made in high school curriculums in the same subjects. Too often the entering freshman from a good high school program is finding himself repeating his work, perhaps even at a lower level.

I would suggest that NSF consider turning over its elementary school science education efforts to the Office of Education, at least the direct financial support aspects; and then act in the role of science consultant to the USOE.

I suggest NSF should take a more active role in encouraging joint programs among educational institutions, especially between a small college and a university.

Support for engineering research including nuclear engineering research should be greatly increased as a recognition of the role engineers can and should play in helping solve many of our national and international problems such as water supply, air pollution, transportation, food production from crop growing through adequate distribution to the ultimate consumer, power production, etc.

22. Based on your own experience in the AEC with educating the public about atomic energy, what future role would you see for the Foundation in educating the public about the nature of this scientific age? What approaches do you think would be the most effective?

22. I suggest NSF should examine its current activities, especially those aimed at the general public as contrasted to those aimed at the scientists. A few possibilities are:

(*a*) A serious attempt to explain to the public the ultimate benefit to society from scientific and technological developments, in language for the layman. Major programs such as atomic energy, oceanography, high energy physics and the space program could all be explained in more day-to-day terms than at present. Too often one has the feeling that the literature of the individual specialized agencies is designed to sell their particular products, without demonstrating the overall national interest and benefit in all types of scientific progress.

(*b*) Better literature on the opportunities for careers in science and engineering, both for the professional and for the technician is needed. Here again, too often literature is designed for a single specialty, or a single agency. In addition, the role of the sciences and engineering in service to humanity never shines through.

(*c*) Several times during the recent President's Conference on Education the need for more study on the history of science was stressed. The NSF should encourage the writing of books and the dissemination of knowledge on this subject. The interrelationship of this topic with items (*a*) and (*b*) is too obvious to comment upon further.

(*d*) All efforts should be devoted to the concept that we have a great need for scientists interested in the humanities as well as humanists interested in the scientists. Therefore, in addition to the literature efforts stressed above, I would recommend that NSF and USOE collaborate on conferences and institutes in which faculty from both the sciences and the humanities get together with people from business, industry, and government to exchange ideas on the nature of big science and its impact upon society as a whole. The AEC has already pioneered in this area with its institutes in Oak Ridge on humanistic studies in science.

RESPONSE BY DR. HUGH L. DRYDEN, DEPUTY ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

1. Since post-Apollo plans are indefinite, and graduate students entering the NASA fellowship program will not emerge until after the peak of the lunar landing effort, what are the inferences and implications as to future Government support of space science in NASA's 1,000 Ph. D.'s per year program?

1. Although post-Apollo plans are not yet firm, any aeronautical or space activity in coming decades will certainly require numbers of highly trained scientists and engineers. The NASA training program was not designed to support the lunar landing effort alone. Its graduates will take part in—and, hopefully, lead—the future program of space and aeronautical science and engineering.

In addition, it is reasonable to assume that new industries will grow from the new technology of space research, and trained people will be needed to staff them. Twenty percent of the Ph. D.'s coming out of the NASA program to date have gone to work in industry.

The target of 1,000 Ph. D.'s per year constitutes NASA's fair share of the responsibility for continuously replenishing the country's trained manpower resources. The number of new trainees entering has leveled off as NASA's total budget has stabilized. An assumption that the United States will try to retain leadership in aeronautical and space science and engineering dictates a continuation of this program to produce highly trained people.

2. Following up your testimony of July 7, to what extent is NASA support of basic research in universities mission oriented? How does it differ, in individual programs, from similar grants sponsored by the National Science Foundation? Would an analysis of random samples from both agencies, other than the Whitford report on astronomy which you mentioned, reveal a characteristic difference?

2. Basic research supported by NASA in universities is expected to yield results which will further the objectives of NASA as set forth in the Aeronautics and Space Act of 1958. This does not mean that all research projects are aimed at specific pieces of hardware or scheduled flight operations. It merely means that NASA concentrates its research support in a region of general relevance to its mission. Accordingly, NASA supports a great deal of propulsion research and little oceanography. Its life science programs reflect much interest in gravitational effects and little in cancer detection.

It is the structure of the research program which is mission oriented, not the administration of each individual project. Examples may be found of NASA grants and NSF grants which are very similar in their general content but different in approach or objective.

3. The future of the Foundation may be changed by the proposal to give to it more responsibility for developing the application of science. If this were done, one aspect of the new responsibility most likely would relate to the NASA technology utilization program. What do you think would be a possible role for the Foundation in speeding the application of the results of federally sponsored research?

3. To effectively apply the results of federally sponsored research in areas, disciplines, industries, and endeavors other than the specific mission for which the research was undertaken demands an intimate knowledge of the science or technology involved as well as considerable familiarity with the problems and objectives of the potential user of the information.

Most investigators who have studied the technology transfer process have concluded that transfer is most effectively achieved when there is a "personal champion" of the technology—that the bridge between innovator and user cannot be built of paper alone. To form such a bridge the disseminating agency must be intimately familiar with the work that forms the basis of the new knowledge.

Agencies such as NASA are accumulating very valuable experience in the transfer process. But in NASA the major thrust has been in action programs with only limited study of the transfer process per se. A logical and useful role for the National Science Foundation in speeding the application of the results of federally sponsored research might lie in that agency's taking the lead in encouraging research aimed at improving understanding of the methods and mechanisms for transfer.

It might organize what is already known on the subject, devise ways of using the information held by the SIE and consider expanding its purview to include engineering and applications, or perhaps involve the combined resources of the National Academy of Sciences and the new National Academy of Engineering.

4. You suggested in your statement that NSF should take the lead in developing a broader base of scientific support, then you added that the mission oriented agencies must give prime consideration to the matter of competence."

> *(a) Does this mean that NASA gives no consideration at all to the geographical distribution of stipends?*
>
> *(b) How about the consideration of individual need—is a means test a factor with NASA in making a decision among applicants?*

4. NASA is very concerned about geographical distribution of extramural support. NASA has active predoctoral training grants at 142 institutions, in all 50 States. This is, however, evidence of NASA's attempt to recognize ability wherever it exists, rather than an attempt to distribute funds uniformly per square mile or per State. Geographically uniform distribution would be as patently unwise as concentration of the effort in a few schools. Some sections of the country have a number of very good universities clustered close together, while others have notoriously sparse academic concentration.

In the statement from earlier testimony, the emphasis is on the word "prime." The important point is that NASA cannot afford to subordinate the accomplishment of its primary objectives to the principle of uniform geographical distribution. As long as competence

remains a foremost criterion, wide geographical distribution of effort is considered valuable to NASA's program, and every effort is made to achieve it.

NASA training grant are made to universities, not to students. The institutions, which select the individual trainees, are not insensitive to the matter of need and would be encouraged to give consideration to relative means if confronted by groups of candidates with otherwise identical qualifications.

However, NASA does not apply a means test. The use of such a test as a qualifying criterion—unless every other training opportunity in the country, public and private, applied the same test—would place NASA at a disadvantage which the program would probably not survive, by placing poverty ahead of quality in the selection process.

5. Along the same line, regarding R. & D. contracting procedures, testimony has revealed that the Department of Defense frequently awards contracts at times when the technical, administrative, and management criteria between several contractors is very close and difficult to decide.

(a) Is this also true in NASA's selection of contractors? If not, what criteria does NASA use in order to make the selection between the top several contractors strictly on merit, and how do they differ from DOD's criteria?

(b) If the selection between the top several contractors is difficult to make, do you then consider geographic consideration to be appropriate? If inappropriate, why?

(c) Has NASA utilized geographic consideration in the past in its contracting procedures, or does it plan to do so in the future?

5. Following the intent and direction contained in the Armed Forces Procurement Act, as amended, 10 U.S.C. 2304, NASA conducts written or oral discussions with those companies which are in a "competitive range"; that is, those which are relatively close as revealed by the evaluation criteria. After such negotiations are completed, it is usually clear which company should be selected as contractor. If two or more companies were in virtually a tie position, the selecting authority would take into consideration the possibility of choosing the contractor which could mean spreading the industrial base and bringing into the program a company which had had few or no prior NASA contracts. Such companies are quite likely to be located in geographical areas which have not had a large amount of contracts.

Other considerations for the selection of a contractor between companies in a close competitive range, as outlined in (*a*) above, might be whether a company is a small business concern or located within a labor surplus area, or in an area which had not received a substantial portion of NASA contracts. All of these factors are considered appropriate and within the intent of NASA's statutory authority.

NASA has utilized geographical considerations in its contractor selection procedures where such locations were necessary, advantageous, or economically expedient. For instance, where contractor-fabricated items were so large that transportation by water was necessary, the location of a contractor's production facility adjacent to water transportation facilities was a criterion for contractor selection. Another example is whether the proximity of supply is a critical consideration, such as propellant storage where the propellant must be

available for use on short notice and where distant transportation would add to the cost.

6. What possibilities are there for cooperative support to develop new centers of excellence through joint arrangements between NASA in-house technical centers and NSF science development program recipients (i.e., Rice University-Manned Space Craft Center, Houston, or Case Institute-Western Reserve-Lewis Research Center, Cleveland)?

6. Two of the NSF science development program recipients are already involved in cooperative enterprises with nearby NASA research centers. Summer faculty fellowship programs have been conducted by Case Institute of Technology in cooperation with the Lewis Research Center, and by the University of Virginia (as a participant in the Virginia Associated Research Center) in cooperation with the Langley Research Center. These programs allow faculty participants to receive both advanced academic training and experience in current research of interest to NASA.

7. In your testimony on NASA's education grants, you said that funds "are made available to the universities with the stipulation that they be used to enhance graduate study in space science and technology." Is this support confined to research? Are the students selected by the universities permitted to teach? Is there a time limitation on their teaching?

7. Funds made available to the university for enhancing graduate study in space science and technology are not confined to research. These funds may be used for such items as—

(*a*) Faculty augmentation—bringing new professors aboard in space-related areas, visiting lecturers, and so forth.

(*b*) Course content improvement—developing new space-related courses or revising existing courses.

(*c*) Acquisition of specialized research equipment.

(*d*) Student travel in connection with trainees' research and study.

(*e*) Other innovative ideas developed by the university which would strengthen the graduate program in space-related areas.

NASA trainees are permitted to teach in those instances where teaching is a departmental requirement for all Ph. D. students. In these instances the student receives his regular stipend but receives no additional payment for teaching.

There is no formal time limit placed on such teaching but it should not ordinarily exceed the minimum teaching requirements as established by the institution.

8. You referred to the fact that NSF's support of quality manpower development is concentrated in postgraduate education. Yet you recognized that high quality graduate students come only via undergraduate production; and you recommend that the Foundation increase its attention to the undergraduate level. Does this recommendation apply also to NASA? If so, how do you propose to implement it?

8. NASA has increased its attention to the undergraduate situation but still does not devote major financial support to, having neither the charter nor the resources to deal with the total problem. Aid to undergraduate education, as such, is considered more appropriately the domain of the NSF and the Office of Education.

On a very modest and selective basis, NASA has experimented with the involvement of interested undergraduates in space-related research and summer institutes in space science and technology. These latter institutes at Columbia University, UCLA, the University of Miami, and California Institute of Technology, have provided 6-week periods of intensive training for gifted undergraduates from all over the Nation.

9. Is NASA supporting, through its fellowship program, any of the social sciences, including political science?

9. Of nearly 2,000 NASA predoctoral trainees, approximately 5 percent are working in the social sciences.

10. How does NASA coordinate its educational support with the National Institutes of Health, the Atomic Energy Commission, the Office of Education, and other Federal agencies that are concerned?

There is nothing I have to add to the discussion of this question beyond the statement contained on pages 13, 14, and 15 of my testimony and the questioning that went on following my testimony.

11. In supporting science education over the humanities or one field of science more than another, does the Federal Government incur an implied obligation to provide employment in the future for those graduates which it has supported? Do the students incur any implied obligation to stay in the field or to work on federally funded programs?

11. NASA does not require, as a condition of traineeship acceptance, any formal commitment by the student to either work in a particular discipline or future Government employment. Graduates are encouraged to engage in research and teaching in the university environment in order to propagate their own kind. A natural incentive to work in space-related fields is provided by the intensive training which a Ph. D. receives in the discipline of his choosing. The national space program will presumably prove challenging enough to attract its fair share of these people in future years. However, should some other endeavor of comparable scope and importance offer more appeal to a particular student, it would be most unwise to force him into another line of work on the basis of a commitment made 4 or 5 years earlier. Even more significantly, the prospect of indentured service at the most productive point in their careers would not appeal to the students of highest competence. These are the ones with no qualms as to their ability to compete in their specialty when they graduate. Any training program with a built-in bias against such highly motivated and confident students would undoubtedly exhibit a swift and irreversible deterioration in the overall caliber of its participants and quality of its output.

The Government does not incur an obligation to provide employment for graduates from the training program. More important, the kind of people who seek and get doctors' degrees in science or engineering are not the kind likely to constitute a future unemployment problem.

12. To what degree do graduate engineers and scientists drift away from their professional vocations into other fields—such as management, trade or commerce, finance, or other business? Is this good or bad? What can be done to improve career counseling?

12. Extensive statistical data are contained in the National Science Foundation report NSF 63–34, published in 1964. That report states,

for example, that in the 1950's about 37 percent of the graduates with bachelor's degrees in science and 85 percent of those with degrees in engineering ultimately entered the fields for which they were trained. This gives no clue, of course, to the number which enter the field and later leave.

Statistical information on particular disciplines may be obtained from such documents as "Physics: Education, Employment and Financial Support," a statistical handbook published in 1964 by the American Institute of Physics.

It is obvious that graduate scientists and engineers do move into other areas such as management. Their talents are frequently invaluable there, and some are better managers than scientists. The important consideration is that they should not be forced out of science or engineering by lack of opportunity.

13. With the advent of the space age the charge has been made that rapid development of space technology has drawn many of the best professors, practicing engineers, and students away from aeronautical engineering into the more intriguing and glamorous field of space engineering, research, and development.

(a) Is this true? and, if so, is it cause for concern?

(b) Is any program in existence or contemplated to assure a balanced input of graduate space scientists and aeronautical engineers in the scientific and technological communities?

13. It is certainly true that examples can be found of professors, engineers, and students who have moved from aeronautical engineering into space research activities. No field of science or engineering remains forever preeminent, and the fundamental reason for the shift of people often lies in the field itself, which may be worked out of stagnant. New fields arise which offer more challenge and more opportunity. One is always concerned when a field as important as aeronautics has important jobs to do and no one interested in doing them. However, one should be equally concerned over any attempt to constrain workers to an older field when a new field is rising. Both space scientists and aeronautical engineers are emanating from the NASA training program. If there are challenges and opportunities in aeronautical engineering good students will seize them.

There has been a downward trend in NASA's attraction of aeronautical and aerospace engineers relative to personnel trained in other disciplines. In April 1962, aeronautical or aerospace engineering was the highest degree of 981, or 14.2 percent of NASA's inhouse scientists and engineers in the aerospace technologies. During the 15 months ending September 30, 1962, 322 or 9.3 percent of the newly hired scientists and engineers had aeronautical or aerospace engineering as the highest degree. The corresponding figure for the subsequent 2 years ending September 30, 1964, was 299 or 7.4 percent.

Of approximately 7,500 scientists and engineers, hired between July 1961, and September 1964, only 84 were teaching professors in aeronautics or any other discipline at colleges and universities immediately prior to their employment by NASA.

The NASA program includes important continuing activities related to aeronautics and aeronautical engineering.

14. Does NASA have any program for attracting older professional people back to school in order to update their technical capabilities?

Are we possibly ignoring or wasting this technical manpower resource? In other words, do we have any program for reeducating older scientists and engineers whose early college training may be obsolete?

14. As part of an effort to insure the updating of skills by the continued training of scientists and engineers, NASA sponsors summer faculty fellowship programs, which are cooperative endeavors between universities and nearby NASA centers. Faculty members usually spend some time at the university in seminars and some at the research center actually engaged in research. In 1965, about 100 faculty members participated in 7 programs which were carried on jointly with 12 universities.

In order to provide biologists with new knowledge about the operational and engineering aspects of space flights, NASA sponsored a two-and-a-half-week program designed to bring 100 faculty and select graduate students to NASA's Wallops Station. The program was undertaken for NASA by the University of Virginia and briefings were given by Government, university, and industrial personnel.

Another activity sponsored by NASA and designed to update skills at the forefront of technology is NASA's resident research associateship program, which involves postdoctoral studies in space science and engineering. Under this program, about 70 postdoctoral or senior postdoctoral participants will come to one of the NASA centers in 1965 to pursue advanced study of special interest to NASA. It was designed to aid in the solution of contemporary problems, provide researchers with advanced knowledge, and to demonstrate new techniques.

In the 2-year period ending September 30, 1964, 36 newly hired scientists and engineers were over 55 years of age, and 195 were between 46 and 55 years of age. Age is not a bar to NASA employment.

15. Does the Science Information Exchange record NASA inhouse project information? Exactly how do you make use of the Science Information Exchange?

15. NASA has cooperated in the provision of input concerning research in progress since the Science Information Exchange was established. Figures compiled by the SIE indicated NASA furnished information on 793 research projects in fiscal year 1963; on 696 during fiscal year 1964; and 338 during the first half of fiscal year 1965.

Under the terms of the NASA–SIE arrangement, NASA provides its complete listings of research grants and contracts awarded. With this information in hand, SIE queries the research investigators directly for specific information relating to the work they are doing or plan to do.

A recent agreement between NASA and the Department of Defense to more effectively exchange information on current research and technology programs has resulted in a standard reporting form No. 1498, by both agencies to facilitate machine processing. Dr. Bisplinghoff advised the SIE on April 21, 1965, that his office will expand the coverage of NASA-sponsored work in the SIE information pool: that recognition must be given to the fact that a sizable proportion of the activity is in a category which does not lend itself to dissemination for a general audience; that, as a result of the NASA–DOD agreement to exchange information on research and technology pro-

grams, SIE will be provided information automatically in 1966; and that during the interim period the information will be reviewed manually in order to increase the coverage of NASA program in SIE files.

Use is made of SIE by program scientists in headquarters or centers who wish to know what work is going on in particular fields. It is used more often by investigators who need to know what other groups are working in their particular areas, and under whose sponsorship work is being conducted.

16. NASA is well known for its studies of scientific and technical manpower. To what extent have your studies or data collection about demand and supply of scientists and engineers for space work been changed or influenced by the Foundation?

16. The National Science Foundation has conducted studies and collected data on overall national scientific and technical manpower over a number of years. These studies have been concerned with the development and dissemination of information relating to scientific manpower resources, and they have been aimed at facilitating national decisions relative to strengthening the scientific effort of the Nation. The information developed in these studies has also served a wide variety of purposes throughout the Federal Government and in the private sector of the economy. In conducting these studies, the NSF has developed definitions and methodology, as well as analysis techniques, which facilitate the measurement and consideration of scientific manpower resources.

In recent years, the National Aeronautics and Space Administration has conducted studies to identify and assess the impact of its program upon national manpower resources, particularly upon scientific and engineering manpower. In conducting these studies, NASA has utilized the NSF definitions of "Scientists and Engineers" and "Research and Development" in order to insure compatibility of results. More significantly, in making our estimates of scientific and engineering employment generated by the NASA program, NASA has drawn much from the NSF data analyses and estimating techniques. Finally, once estimates of NASA manpower requirements have been developed, they have been related to the overall NSF estimates to determine the impact of the space program upon national resources.

17. The point has been brought out during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded say, by agency X, agency Y, or both. More specifically:

(a) What guidelines or criteria has NASA established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the agency's jurisdiction and, therefore, should, or should not, be supported by NASA?

(b) If written criteria have been established, please submit a copy thereof to the committee.

17. NASA project managers are guided by their total knowledge of their program objectives, specific progress toward those objectives, and work in existence elsewhere. Individual judgment plays a large part in

the selection of projects for support. In only a few fields, such as astronomy, have written guidelines been established to delineate NASA's area of support vis-a-vis that of NSF.

18. NASA and the Foundation, among other Government agencies, draw heavily upon the advice of the scientific community. It would be useful were you to compare the ways in which NASA and NSF obtain such imput for the shaping of your major scientific programs.

(a) In particular, how do you define this "scientific community"? Having done so, how does one know that the scientists consulted reliably represent the best in scientific thought?

(b) What paths are left open—formal or informal—for divergent views when your agency chooses to consult the scientific community?

18. For this purpose, "the scientific community" may be defined as the people who actually engage in or direct scientific research.

It is never possible to know *a priori* what represents "the best in scientific thought." What is best is simply what turns out to be nearest to fact, or physical reality, and this ultimate truth is an elusive thing. Scientific opinions are perhaps different from those in other areas, however, in that they can often be subjected to the test of experiment. Hence, an estimate of the reliability of a particular scientist usually involves appraisal of his past performance, his reputation in his field, the breadth and depth of his experience, and his perception of the immediate problem.

Scientists thrive on diversity of view. Any attempt to suppress divergent opinions is probably less successful in the scientific community than any other. Free discourse is encouraged, and NASA tries to get various viewpoints on every important issue. Scientific dissenters are not usually reluctant to express disagreement, however, and if formal channels do not satisfy them, they seldom hesitate to argue their points with their colleagues, present them voluntarily to the agency, or publish them in the open literature.

Response by Dr. Don K. Price, Dean, Graduate School of Public Administration, Harvard University, to Questions of the Subcommittee on Science, Research, and Development

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1. In your testimony on July 7 you answered in the affirmative your own question as to whether science can get large-scale Federal support without running the risk of political interference. Accordingly:

(a) What has happened to private sector support of science education in the face of increased Federal spending? What proportions of graduate science students are self-supported or receive non-Federal fellowships?

(b) Is the Federal fellowship program adversely affecting the programs of private foundations because of more attractive terms?

(c) How can the relatively low science education budget of the National Science Foundation act as a balance wheel against the large sums spent in institutions of higher learning by mission-oriented agencies? Should not the NSF have a say in how all Federal basic research funds are allocated?

1. There is no question that the large-scale Federal support of science has led some private foundations and other donors to turn to other fields of knowledge. On the other hand, it is my impression that private funds for the support of scientific research and science education have held up surprisingly well. The generous level of certain Federal fellowship programs has certainly required private fellowship administrators to reconsider the size of their stipends. This is awkward for them, and resented by those who recall the difficulties they had in financing their own graduate education, but in the main the adequate provision of fellowship assistance seems to me a desirable policy. As for the "balance wheel" function of the National Science Foundation, it would obviously be more effective if the Foundation had a larger budget, but it serves a useful purpose even as a small fraction of the total. I find it difficult to imagine any feasible arrangement that would give the NSF an authoritative voice in determining the allocation of basic research funds granted by other agencies; it can of course exercise some influence by the advice that its staff may give either on a voluntary basis or as a part of the deliberations within the Office of Science and Technology or the Bureau of the Budget.

2. You said the basic procedural safeguard for the independence of scientific institutions from centralized bureaucratic control is provided by the NSF advisory panels, on the principle, as you put it, "that there be no subsidization without representation." In this connection:

(a) There have been allegations that the same advisers, or advisers from the same institutions, frequently serve as consultants

to a number of Government agencies and that this causes the danger of (1) inbreeding of a limited type of favorite research projects, and (2) an elite group of people or institutions in certain geographical areas. What steps can be taken or have been taken to assure that this does not occur?

(b) Are the panels dominated by "big university" membership?

(c) Are small colleges adequately represented?

(d) How about private agencies—including foundations, research institutes, and industry?

(e) Has the use of advisory panels to evaluate research proposals lessened the competence of the Foundation's in-house scientific personnel? Who makes the final decision as to whether a particular project should be supported?

2. To be completely certain that no class of colleges and universities would be specially favored by advisory panels, it would of course be necessary to have such panels made up entirely of people from institutions which did not receive grants. This is obviously not feasible; the system will run only if those who have special knowledge—who are inevitably employed in the types of institutions working in those fields of knowledge—serve on the panels. To prevent inbreeding and favoritism, it is surely desirable to have a reasonably diversified base of membership and to include some panel members, wherever possible, from nonacademic institutions. It would be quite wrong, it seems to me, to say that there is no problem here to worry about. On the other hand, it seems to me that it is a problem that has been handled reasonably well and one that it is impossible to make absolutely pure without rendering it sterile. The most important safeguard, it seems to me, is to have an adequately strong staff with high scientific competence within the Foundation; in the past I am inclined to believe that the great extent of reliance on the outside advisers has probably prevented the development of adequate career staff.

3. In your recent review in the May 7, 1965, issue of "Science," you identified as a fundamental question: How is science, with all its new power to be related to our political purposes and values, and to our economic and constitutional system? As one of the leading students of this question, what is your answer?

3. The fundamental question of the relation of science to our political purposes and values, and to our economic and constitutional system, is of course a question I treated in my most recent book, "The Scientific Estate," a copy of which I recently sent you.

4. You imply in your "Science" review that the early close relationship between scientific and political ideas that characterized the age of Franklin and Jefferson should be revitalized, particularly to strengthen us in our competition with the Marxists who teach that their system is the only approach to politics that is firmly grounded on the scientific method. Do you think it reasonable and desirable for the National Science Foundation to take the lead in such a revitalization? How might this be done?

4. The broad political question of the relation between scientific and political ideas does not seem to me to be the special mission of the National Science Foundation. Obviously it would be desirable for the officers of the Foundation, like all political and administrative leaders, to have an appropriate philosophy in this respect, but I doubt

that they have any particular reason to take the lead in formulating such a philosophy.

5. It is now 10 years since you published "Government and Science." In it you emphasized the importance of applied science both to the forming of our present Government and to its early economic growth. Considering this, what are your thoughts about assigning more responsibility to the Foundation for the application of the results of Government-sponsored research and development?

5. I am rather dubious that the responsibility for the application of the results of Government-sponsored research and development should be assigned to the National Science Foundation, although I would not like to draw a rigid line in this respect to preclude the Foundation from this field.

6. With respect to national science policy, which you discussed at the hearing, do you feel any clarification is needed in the policymaking roles and relationships of NSF, the National Science Board, the Office of Science and Technology, the Federal Council, the President's Science Advisory Committee, the Special Assistant to the President for Science and Technology, and the National Academy of Sciences?

6. I am rather inclined to think that the basic relationship of the NSF to the various parts of the Executive Office of the President, and to the National Academy of Sciences, is sound enough but I dot not think that "policy" is something that can be neatly parceled out among different agencies, and I do not worry very much about the need for complete clarification in the policymaking roles.

7. What problems in the area of science policy do you believe in need of resolution and policy formulation? To what extent do you feel that the present formulation of policy is being adequately reported to the public and to the Congress?

7. The principal area of science policy that seems to me to need policy attention is the relationship of the support of research to the general support of higher education. I am inclined to believe that the work of your subcommittee and others is making a good beginning on this problem. It seems to me to be hampered not by any secrecy but by the normal inertia of the political process.

8. It was brought out at the hearings that a considerable transition has occurred in the character and content of college education in science and engineering in the last quarter century. Is it true that today's academic engineering is not only new and more comprehensive, but actually supersedes or perhaps controverts some of the principles that our engineering colleges taught in the 1920's and 1930's?

8. I do not feel competent to comment on the curriculum problems in engineering colleges.

9. What has been done to attract older professional people back to school in order to update their technical capabilities? Can you report any effective countermeasures to academic obsolescence in science personnel?

9. I hear of various midcareer "retread" programs for scientists and engineers, but I know too little about them to make any effective comments.

10. The best graduate students are frequently unavailable for teaching because the terms of their research fellowship specifically prohibit this activity. Do you believe more research grants should permit some

teaching, to provide flexibility to the graduate and to help in the training of undergraduates?

10. I do indeed believe that research grants should make it possible for research workers, wherever appropriate, to undertake some teaching.

11. As a scholar in government organization, do you believe that the scientific disciplines should have more representation in our legislative bodies? If this is desirable, how might we go about inducing more scientists and engineers to run for public office?

11. I would be happy to see more interest in political activity on the part of any group of citizens, including scientists and engineers, but I do not think that elective office is the only form of participation in public life, and I do not think it is surprising (or particularly undesirable) that scientists and engineers are temperamentally somewhat less inclined to run for office than, for example, lawyers.

12. In your teachings and writings, are you comfortable in relying on the statistical data, particularly with regard to manpower, which NSF accumulates and correlates?

12. The NSF data are certainly the most complete and reliable to be found in any country. The data with which they deal are very slippery, and I have no doubt that a continuous effort toward improvement is warranted. I have not really worked on this problem for some years, and have no particular suggestion for such improvement.

13. Has the NSF provided leadership in the effective coordination of the scientific information activities of the Federal Government with the view to improving the availability and dissemination of scentific information since March 1959?

(a) Has the transfer of fiscal and managerial responsibility for the Science Information Exchange to the Foundation strengthened SIE?

(b) Is the academic community concerned with the field of science and public policy satisfied with statistics and analyses developed by NSF?

(c) What other information and studies are needed? Should these be undertaken by NSF or by others?

13. I have really not followed this story closely enough to have a useful opinion.

14. Section 3(a)(2) of the National Science Foundation Act which authorizes the Foundation to support basic research carries the additional provision that the Foundation is "to appraise the impact of research upon industrial development and upon the general welfare." What has the Foundation done to carry out this provision?

14. I suspect that the section of the act proposing that the Foundation is to appraise the impact of research upon industrial development has not been very effectively carried out.

15. How are Foundation's so-called free funds to universities controlled so as to prevent, for example, their being used possibly to meet unreimbursed overhead costs? Would an improvement in indirect cost allowance policy negate the need for some of these funds?

15. The payment of full indirect costs seems to me to be wholly desirable policy. Obviously this would reduce the temptation to divert funds improperly to purposes not intended by the terms of grants. I have not been personally close to the administrative problem of con-

trolling the use of the so-called free funds and consequently have no comment on this problem to offer.

16. What contributions have the small college and the young unknown investigator to make toward the betterment of science? What specific effort does NSF make to assist them and take advantage of their potential?

16. As a former officer of a private foundation, I can only be sympathetic with the plight of the National Science Foundation in simultaneously trying to make high quality grants, and also give help to the small institution and the unknown investigator. I think this is a dilemma that it is impossible to resolve except by judicious compromise. With more staff the Foundation could doubtless make a more thorough search for talent in the small institutions; how soon they would reach a point of diminishing returns could only be found by experiment.

17. The Foundation in recent years has devoted some funds toward improving science teaching as well as curriculums in undergraduate as well as high school levels. Based on this experience, do you believe that fellowship or institutional support of pregraduate education should be proportionately increased or decreased?

17. I do not feel competent to comment on this question.

18. In your judgment, what proportion of scientists and engineers should have the Ph. D. degree? What is the dropout or failure rate in Ph. D. aspirants?

18. I fear my ignorance extends also to this question.

19. Do you feel that in fulfilling its balance function, the NSF was intended to play a special role in considering geographical dispersion of science support? Has this been done?

19. Certainly some of those who originally proposed the creation of the National Science Foundation hoped that it would take geographical location into account in distributing its funds; other wished it to make its awards strictly on scientific merit, and were terribly afraid of some quota system imposed to meet political demands. In recent years the Foundation seems to have been worried, with good reason, about the need for geographical spread in its grants, and while I have not been on the inside of its operations I assume that that concern has had some influence on its program.

20. Should the Foundation devise and adopt a deliberate policy of distribution of support that is counter to that of other Federal agencies? Has the situation in American science changed sufficiently over 15 years that the Foundation should today avoid support of existing centers of excellence? Would the impact of the Foundation be greater under such a policy?

20. It seems to me that the question of geographical distribution deserves consideration only within the context of the essential purpose of the Foundation. If it is expected to improve the quality of science in the United States, it seems to me that it would be a great mistake to force it to distribute funds in relation to the accidental quality of geography, without regard to the quality of the science in question. I would, for political reasons, be strongly in favor of an effort to build up a limited number of institutions of high quality in regions which now possess none, or few, of such institutions. But it seems to me the first and overriding consideration should be the support of quality, and to avoid the support of existing centers of excellence would destroy the Foundation's program.

RESPONSE BY DR. ALVIN M. WEINBERG, DIRECTOR, OAK RIDGE NATIONAL LABORATORY TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

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1. In your testimony on July 8 you referred to the 15 percent increase in the budget of the National Science Foundation for 1965 over 1964 and said that you "strongly urge that this trend be maintained or even accelerated so that by 1970, NSF's budget would exceed $1 billion per year."

(a) What about after 1970? Should this growth rate accelerate further, remain at about 15 percent, or level off? What limits the ceiling?

(b) What is your concept or understanding of the base upon which the 15 percent rate is or should be calculated? NSF support of basic research? Fellowship grants, facility development, or what?

1. (*a*) It is very difficult to predict the situation more than 5 years hence. In general, since I visualize NSF becoming primarily[1] (though not exclusively) the supporter of basic physical research in the universities, the growth of NSF should be related to the growth of the universities. Assuming that a fixed fraction of our university students continue to go into science, as the university population grows, the number of science students will also grow. I would therefore hope NSF will continue to grow well beyond 1970, and at a rate determined by the growth of the universities.

Probably NSF should not grow quite as fast as the universities, however. I do not believe that science is the *summum bonum* of our culture, and I therefore do not advocate pushing Federal support, particularly of the physical sciences, above all other activities, Eventually, therefore, NSF's budget should be a certain fraction of the GNP; in this sense, support for basic physical science in the universities will reach some level which is also related to the GNP. I don't believe this should happen, however, until well past 1970.

(*b*) I believe that 15 percent should be divided mostly between support of basic research and facility development; my impression is that, with the passage of the National Defense Education Act, fellowships are not the problem. I believe that the projectizing of support of basic research has been carried far enough, and much more attention should be paid to the geographic distribution of funds for basic research. I favor doing whatever can be done to upgrade scientifically

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[1] Some who read my testimony have interpreted my remarks as advocating that NSF reduce its support of the basic biological sciences. I do not advocate this: to me biological science will always remain an important field in NSF. I do foresee that its position relative to physical science in NSF may diminish, not because biology decreases but because physical science increases more rapidly.

backward parts of the country—by facility grants, center-of-excellence grants, etc.

2. If Federal funding for R. & D. continues to level off and is not compensated by corresponding growth of support from the private sector, will the future demand for scientists and engineers, other than for teaching, also drop and will this influence future student enrollments in science and engineering?

2. If Federal funds for R. & D. level off, eventually the number of students choosing to study science will drop. However, there is an enormous backlog of unfilled places in science—not so much in research as in teaching. I believe that our country's smaller colleges and high schools need many more, truly competent teachers of science and mathematics. To fill this demand will take many years.

3. In your contribution to the National Academy of Sciences report to this committee, you refer to basic research in the physical sciences being faced with a deep financial crisis, presumably arising because of leveling off of mission-oriented agency budgets. Is there a similar crisis in support for applied research in the physical sciences?

3. I don't believe one can speak of a "crisis" in applied research in the same sense as I spoke of a crisis in basic research in physical sciences. Basic research is motivated primarily by the individual doing the research. Hence the desirable size of the overall basic research effort, as seen from the viewpoint of the basic research community, is determined internally by the separate desires of the individual researcher. To some degree, but only to a degree, our society feels an obligation to support every truly competent basic research scientist. To the extent that there is not enough money to support the growing requirements of the expanding number of basic researchers, a crisis has developed.

Applied research is extrinsically motivated; it is done not primarily because it is of interest to the scientist performing the research (though it may be very interesting to him) but because it is needed to support some project. Thus the fortunes of applied research wax and wane as old projects are completed and new ones are started. The "desirable" overall level of support for applied research is pretty much determined by the needs of the projects rather than the desires of the applied scientists. Individuals doing applied research tend to understand this. Though they are naturally unhappy if a project to which they are attached is canceled, they understand that their claim for support rests upon their contribution to a project, not their intrinsically motivated contribution to general knowledge. One therefore can't speak of a "crisis" in applied science in that there is not enough money to support every good applied scientist. The needs of the applied scientist are largely a reflection of the needs of specific applied projects: both he and his funding agency usually recognize this.

This is not to say that the position of applied science in this country does not need strengthening; in fact, it is suffering from a kind of intellectual crisis. I am very sympathetic with Edward Teller's concern about the relatively poor place of applied science in our universities. But I believe he was referring mostly to the place of applied science in the university's intellectual hierarchy, rather than to its financial support.

*4. The 1970 projection you outlined to the committee envisioned "NIH being concerned primarily, though not exclusively, with the physical sciences; NSF primarily, though not exclusively, with the physical sciences * * * and with those aspects of science that are not properly taken care of by one of the mission-oriented agencies."*

(a) Does the latter include the social or environmental sciences?

(b) Do you believe that NSF funds should be oriented in the future to support applied research on new problems of society such as pollution, urban transportation, and housing? Should such funds support this research in those in-house or contract centers that have high competence but are suffering from obsolete missions?

4. (*a*) I think NSF is a proper home for basic research in the social sciences. I am less clear about the environmental sciences. I have the impression that with the reorganization of the Department of Commerce's environmental science work into a single administrative unit, the Government now has a mission-oriented agency that could take responsibility for basic research in at least certain phases of environmental sciences.

(*b*) I don't think NSF should be used to any great degree to do the research necessary to get on with solutions of our great sociotechnical problems. Rather agencies or departments, once set up to deal with these problems, should have research departments that support the scientific work needed to carry out their missions. Thus urban transportation and housing research ought to be the primary, though not the total, responsibility of the new Department of Urban Affairs; pollution, the responsibility of Interior; and so on.

I agree that contractor establishments of high competence should be deployed to meet the most important problems, whether or not these problems fall precisely within the domain of the establishment's original interest. So to speak, we need governmental laboratories as well as governmental agency laboratories. I would look to the Office of Science and Technology, working with the agencies and with laboratory management, to achieve such redeployment as efficiently as possible.

5. You spoke of the "rivalry between university and Government laboratories." Should more intimate cooperation be developed in graduate education and research between federally supported university science departments and Federal in-house research and technical centers?

5. I strongly favor developing educational ties between Federal laboratories and nearby universities, especially in some of the educationally less developed parts of our country. Here in Oak Ridge we have had considerable success in encouraging cooperation with neighboring universities. I think the Oak Ridge pattern can serve as a model for much of our country.

6. Are you satisfied that the Federal agencies have accepted and are discharging their responsibilities for information activities in fields relevant to their missions? To what extent do you consider that the recommendations of the President's Science Advisory Committee Report of January 1963 on Science, Government, and Information have been implemented? Can you suggest areas where you believe improvement is necessary?

6. I feel that I am no longer close enough to the information problem to offer a fully informed opinion. My general impression is that the Office of Science and Technology has moved aggressively and intelligently in this field, that COSATI is working well, and that the agencies take information far more seriously than before. As for implementing the recommendations of the PSAC report, I am satisfied that as much has happened as one could reasonably expect. In particular, the central role of the specialized information center has been recognized and strengthened.

7. Exactly how do you make use of the Science Information Exchange? What is your impression of its operation and utility since responsibility for it was assumed by NSF?

7. I have not followed the progress of SIE since its takeover by NSF.

8. The point has been brought during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. Specifically:

(a) What guidelines or criteria has the Oak Ridge Laboratory established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the Laboratory's jurisdiction and, therefore, should, or should not, be supported?

(b) If written criteria have been established, please submit a copy thereof to the committee.

(c) Should NSF support basic research at laboratories such as Oak Ridge?

8. (*a*) and (*b*). In response to your question, I should make clear that ORNL is an Atomic Energy Commission Laboratory. We almost never are called upon, as a laboratory, to support basic research originating outside the Laboratory. Hence questions 8 (*a*) and (*b*) are not applicable.

(*c*) In general, I would not visualize NSF supporting work directly at the mission-oriented laboratories such as ORNL. However, there may arise instances where a mission-oriented laboratory is uniquely qualified to undertake non-mission-oriented basic research that relates closely to some interest of NSF. In this case an exception to the previously stated principle might be countenanced, but I should think that such cases would be rare.

9. Considering the Foundation's interest in manpower development, should the Foundation undertake programs concerned with retraining? What, in your experience, is the best technique to avoid premature obsolescence of scientists and engineers?

9. I am not persuaded that "retraining" is a real problem. I think a more urgent problem is maintaining the sense of mission and purpose of the institutions at which older men work. If new missions are identified that are of great interest and about which people can generate great enthusiasm, then the problem of obsolescence can be largely avoided. So to speak, the problem of obsolescence is not so much that the individual scientist becomes obsolescent as it is that the management becomes obsolescent. I doubt that NSF can contribute much to keeping management on its toes.

Response by Dr. Charles Kimball, President, Midwest Research Institute, to Questions of the Subcommittee on Science, Research, and Development

1. You made the point in your testimony that the National Science Foundation should develop a new program aimed at training certain gifted individuals to be "appliers of science." Would you state in more detail how NSF would go about setting up such a program. What would be its specific objectives? How would individuals be selected? What training would they receive and where? What role could the nonprofit research institute play?

1. A program to train scientists in the social, political, and economic relevance of technology deserves careful attention. If NSF undertakes an effort of this type, it need not and should not be totally separate from existing NSF programs. I suggest incorporating such objectives, specifically in certain existing NSF educational programs.

But the whole task does not need to be undertaken by NSF directly. We need experimentation with different approaches before any policy in this area can be finally set. I have suggested in my testimony of July 8, 1965, that the business schools might logically take on young scientists and engineers, instructing them about the "market value" of technology, and the influence of the marketplace in judging the value of scientific effort.

The independent research institutes can and should help in several ways. First, in MRI's case, we plan to experiment by exposing a few talented candidates for science and engineering Ph. D.'s to the kind of intense conferences we have been operating at Andover, N.H., for the Engineering Foundation over the past 3 years. This would offer a short-term but very intensive exposure to the social, economic, and political consequences of technology for young people, who have spent most of their time in a more protected and isolated academic environment.

A second model which we would like to see expanded, we have for 4 years involved many of our own scientists and engineers in technology utilization programs we operate for NASA. The experience has proved beneficial both to the technical people and to the industrial economists concerned with the program. Everyone's view has been broadened.

We now hope to extend this approach another step—to develop another model which might prove useful to NSF and others concerned with the national issues of applying technology in the public interest; i.e., fellowships at the Institute to bring senior scientists from the world of basic research into a pragmatic environment for a year or two at a time. These could be men from universities, Government laboratories, or from the basic research laboratories of private corporations. The exposure they would receive in an institution like ours to

many different types of research programs, and to the constant pressures for effective solutions within time and cost boundaries, should be an energizing and stimulating experience. We have no doubt that such men will also contribute both depth and new insights to our own staff.

We think these kinds of approaches may offer an answer to several questions: (*a*) exposure of young scientists and engineers to "real world problems;" (*b*) a means of retraining and revitalizing mature technical people whose skills may be going out of date; (*c*) a means of further breaking down cultural barriers between basic and applied research.

Finally, on this point, we hope to undertake this program with the support of private foundations. We see this as an opportunity for the foundations to contribute experimentally to new approaches which NSF and other Federal agencies may later wish to pursue.

As I expressed in my cover letter to Chairman Daddario, questions No. 8 and No. 11, which refer respectively to the retraining of scientific and engineering personnel and the role of the fellowship program of the Federal Government are answered to some degree implicitly in the above response. In addition, I have responded explicitly to questions No. 8 and No. 11 later in this memorandum.

2. Some witnesses have suggested that NSF should not become too involved in the area of applied research because it would require a different type of organization and the Foundation's primary purpose of supporting basic research might be neglected. How would you answer such critics?

2. I question the utility of trying to draw hard-and-fast distinctions between basic and applied science. But in my view, the Foundation's primary task of supporting basic research should be continued and perhaps intensified. It would not necessarily be destructive of this primary purpose for NSF to become involved in some areas of applied research, because the latter type of effort can often suggest and uncover needed areas of basic research. It is generally recognized that gaps in basic knowledge frequently become evident in applied science programs. Our own 20 years' experience at MRI has illustrated this in a large number of instances.

3. How much of the research done by the Midwest Research Institute can be categorized as basic research or, as you put it, "research for opportunity"? Please state it in percentage, if possible.

3. Few scientific research projects are either all basic or all applied in content. Furthermore, few scientists can agree about the precise content of either type of research in a given project. Few of MRI's applied projects do not have some basic content. Currently, between one-quarter and one-third of our total scientific effort, distributed among approximately 125 different projects, is basic in nature.

4. Would NSF support be helpful in pursuing such basic research as you may be doing?

4. Yes, through supplying funds for pertinent equipment, for beginning certain in-house generated projects, and for contracts to study the process of technology transfer and science application.

5. You stated or at least implied that the pursuit of applied research generates many opportunities for profitable work in basic research. Would you elaborate on this point?

5. See answer for question 2.

6. At present several departments and agencies—including NASA, the Department of Commerce, and the Atomic Energy Commission—have technology utilization programs aimed at fostering the commercial application of the results of their research and development. What might the Foundation do to bring about a better understanding of the processes of technology utilization and to lead these agencies toward a common approach?

6. I view with concern, any attempt on the part of NSF to quarterback or arrange for central control for the technology utilization programs now going on in NASA, Commerce, and AEC. Rather, NSF might well sponsor research on ways to improve the effectiveness of the technology utilization process. There is no necessary virtue in having all of the agencies employ a uniform approach.

7. A number of witnesses noted that the Midwest is a leading producer of Ph. D.'s, who subsequently work elsewhere. Do you see a role for the Foundation in obtaining a better understanding of this tendency? What might this role be?

7. NSF could sponsor research on the kinds of patterns which Ph. D.'s having Midwest origins follow; in effect, an origin/destination study of the Midwest's educated scientists and engineers. Some work has been done on this, but mostly on an ad hoc basis—much more is needed, including projections and reasons for moving and returning.

8. Based on your experience as director of a research laboratory, what responsibilities do you think desirable for the Foundation for the retraining of scientific and engineering personnel whose specialties have become obsolete?

8. This refers to an essentially new form of education in the scientific field (with the exception of medicine which has been practicing this for a long while). In many ways, the university curriculum should anticipate this "retreading" need. The recent Weinberg article in Science illustrates this. Postdegree fellowships for men 5 or 10 years out would be one example. NSF could also work with the Office of Education and the Office of Manpower and Training to help these groups set up adult/vocational education programs with emphasis on part-time study, while employed.

9. You suggested the idea of internships to give scientific and technical personnel more insight into economic factors of applied research and development. How would these internships compare with existing Federal fellowships given by the Foundation?

9. My suggestions about internships (see reply under No. 1 above) relate to the need for acquainting new science Ph. D.'s (and other graduates as well) with the facts of nonuniversity research life. This may best be accomplished outside a university. Dr. Teller alludes to this in his recent statement before the Daddario committee.

10. In your view, which is the more important function of the Foundation—the promotion of scientific research or the advancement of science education?

10. The promotion of scientific research is the most important function of NSF. The advancement of scientific education, in the context of my testimony, is a means to that end.

11. Is the science fellowship program of the Federal Government adversely affecting the programs of private foundations because of more attractive terms?

11. I am not to well informed on the Foundation's science fellowship program but it is, I believe, a competitive force in a scarce talent market. It could adversely affect the recruitment efforts of institutions like MRI and industry, by further biasing new graduates in favor or working chiefly on public problems supported by Federal funds.

12. How can the relatively low science education budget of NSF act as a balance wheel against the large sums spent in institutions of higher learning by mission-oriented agencies? Should not NSF have a say in how all Federal basic research funds are allocated?

12. By an overt NSF policy of minimizing overlap, and by acting as a compensating factor in funding fields currently undernourished by mission-oriented agencies, NSF might try to obtain matching fund grants in these undernourished areas from mission-oriented agencies to increase its own effectiveness. I do not believe that NSF should have an overall jurisdiction on how our Nation's basic research funds are allocated. But it can well be a considerable influence in pointing out omissions or dead spots which are significant in the national interest.

13. From the standpoint of objectives, program content and management, which of NSF's programs do you consider to be the best, and which do you consider to be the least useful?

(a) What are NSF's notable weaknesses or deficiencies, and how may they be corrected?

(b) What more could the Foundation do to promote the progress of science?

13. I am not sufficiently informed in adequate scope and depth about all of NSF's efforts, its strengths, its weaknesses, to answer this question meaningfully, without considerable additional study.

14. Another function of the NSF is to collect information about research and development activities. Considering current interest in regional distribution of Federal research and development, what information do you believe the Foundation should collect to adequately show this distribution?

14. The question suggests that the information about geographical distribution of Federal R. & D. funds is not now adequate. We probably need a better definition of R. & D. to offset some misleading figures that may be associated with large testing or operational sites, but beyond showing where the money goes and where the federally funded people are, I have no suggestions. This is an area which deserves additional study.

15. What would be a logical means of measuring the equitable region distribution of Federal science funding—i.e., dollars per State, dollars per capita, Federal technical center or university science center location? In other words, if the Congress should instruct the agencies to purposefully add dispersion criteria to their grants and contracts award procedures, how should the results be measured?

15. There is no one logical means for measuring equitable regional distribution. One suggestion is that States, or institutions in those States, would meet certain thresholds of performance criteria, and might then be eligible for institutional (nonpersonal) grants for generating further capabilities, as is now done by NASA. But Federal dollar inputs should be measured against performance of centers of

competence and not just by proportionate criteria. They should not attempt to "make the competence" from a standing start. NSF could also act in this instance as a balance wheel by overtly helping regions in which the Nation needs or wants to see scientific development take place. In this way, schools and institutions and States which are outside the current "establishment" could well be encouraged and advanced.

16. Could independent research institutes such as MRI take on more of the applied research and contract center operation, freeing the universities for basic research and education?

16. I question the use of the term "freeing" the universities for basic research and education. Most universities have moved into the applied research and contract center business by planned action.

17. In your testimony you mentioned that grant-type support of research was incompatible with contract-type support. Do you mean by this that, were the Foundation to extend its interests to applied research, it would have to turn to grants? If so, what are the respective features of grants and contracts that lead you to this conclusion?

17. Grant-type support is not incompatible with contract-type support. Grant support is incompatible with the needs of many organizations (like most research institutes) who cannot afford to subsidize projects having inadequate grant overhead allowances. It is my understanding that many universities with a large number of grants also have to provide supplemental funding from their own funds.

The grant or contract mechanism itself is not so important in the context of this question, except that people working under contracts are usually expected to provide definite results, where as grants by tradition are viewed largely as financial support mechanisms. The difference here lies in the degree of expectations of results.

18. Do you see any danger of NSF becoming a "creature of the universities"? Are NSF's operations allied too much with the universities? Do you believe that NSF policies are controlled and set too much by those associated with universities?

18. Universities do exert very considerable influence, both directly and indirectly over NSF. Because basic research is regarded as the main province (in the research sense) of the universities, and because NSF is currently concerned almost entirely with basic research, operations are a closed circle. As I said in my text, there are other institutional forms that could make considerable contributions here.

In closing, I think it is appropriate to quote from "The Pursuit of Excellence, etc.," by John Gardner, a remark which well summarizes this issue facing NSF and the Nation: "There is a danger of training scientists so narrowly in their specialties that they are unprepared to shoulder the moral and civic responsibilities which the modern world thrusts upon them. But just as we must insist that every scientist be broadly educated, so we must see to it that every educated person be literate in science. In the short run this may contribute to our survival. In the long run it is essential to our integrity as a society."

Response by Dr. J. J. Rabi, Professor of Physics, Columbia University, to Questions of the Subcommittee on Science, Research, and Development.

1. In your testimony on July 13 you spoke of science as the "intellectual currency" of our time. From your viewpoint as a member of the NATO Science Committee, how has the political stature of the United States grown by virtue of its scientific effort? Can you give examples?

1. I will answer this question by giving some examples:

(*a*) The CERN Laboratory was organized to a large degree on the example of the Brookhaven National Laboratory, and an invitation to Brookhaven National Laboratory is considered a high honor anywhere in the scientific world. At the present time, there are over 100 foreign scientists working in Brookhaven.

(*b*) The large number of foreign scientists in various western countries are getting an important part of their support through U.S. agencies, and this support is concentrated in the most advanced portions of the discipline.

(*c*) In the NATO Science Committee almost all the initiatives come from the United States. Most of the proposals, although by no means all, which we consider sound are accepted. These examples show that the United States has acquired a leadership position in this field which spans the intellectual community and has raised acceptance of the United States on the political side by virtue of its power and continuing accomplishment. We are respected and have a great deal to offer apart from direct support. In this connection I should like to note that at the beginning of the NATO Science Committee the United States contributed 50 percent of the budget, and we are now down to 24.4 percent of the normal NATO contribution, which shows the degree to which the NATO Science Committee and its program has been accepted by the member states and their treasuries.

2. How do you think that U.S. capabilities in science and its support by the Federal Government should be utilized (a) to strengthen international science and (b) to help achieve U.S. foreign policy objectives? What is NASA's proper role in this regard?

2. (*a*) The United States should aim in the future to strengthen international science through its own scientific contribution and example rather than to continue indefinitely to support international science financially. Certain kinds of support which advance important U.S. science programs, of course, should continue.

(*b*) U.S. foreign policy objectives are best achieved, in my opinion, by U.S. excellence and willingness to cooperate. Again, I would like to emphasize that direct financial support should be at a minimum, but cooperation in making knowledge, and in some cases techniques and instruments available would be most effective, as would be visits of foreign nationals properly selected and supported.

I do not understand the NASA program sufficiently well to comment.

3. Assuming that support of an international program has certain political or prestige benefits for the United States, how is this transferred into dollars and cents and how does it relate to the scientific merit of the program?

3. It is my belief that prestige benefits in science ultimately flow into dollars and cents as do prestige benefits in industry, banking, or show business. U.S. scientific equipment becomes more readily salable, U.S. publications find a readier market and ultimately products of U.S. scientific industry.

4. The Foundation itself is not supposed to determine science policy questions, yet the level of support to be given a politically advantageous international program would appear to be a national policy matter. In such a case who does, or who should, determine the overall level of U.S. support?

4. As I suggested in my testimony, there should be a close relation between the Foundation and the other Government departments such as State, Defense, Commerce, and HEW, as well as OST.

5. What is NSF's role regarding overall coordination and funding in relation to the activities of the State Department on the one hand, and the Federal Council and the Office of Science and Technology on the other?

5. I am sure this question is better answered in other testimony.

6. In an international program where a number of Federal agencies participate, should the agency primarily responsible for the program fund for all the agencies involved, thereby presenting the program in a complete package rather than in a piecemeal fashion which may be subject to irregular budget cuts by different congressional committees?

6. I will agree that this is desirable, especially when a greater use could be made of the Federal Council of Science.

7. Following up your discussion with some members of the committee on the relative worldwide emphasis on the physical sciences as compared to the social sciences, would you say that the issue essentially boils down to this: We have learned in this century how to destroy civilization; the question is, have we learned not to? Do you have an answer to this question?

7. We already know how not to destroy civilization. There are plenty of economic, sociological, ethical, and political answers to this question. We have known for ages how to destroy civilization as witness the destruction of the Roman Empire, the Moslem Empire, the Greek Empire of Alexander, and the great empires of the Mongols. Science has taught us in the last few centuries how to create a civilization where there need be no want, no hunger, no superstitious fears, less disease and human suffering, greater communion of nations through better communication, faster travel, more economical transportation. What more do you want?

8. Are any problems raised, such as future support of worthwhile projects, by the termination of international research programs?

8. I recommend that when worthwhile projects are due for termination that the United States do everything possible not to make this termination too abrupt and cataclysmic. We should arrange with the

country in question either a takeover or a gradual reduction and try as far as possible to develop other means of support.

9. What is the nature of the coordination of Federal support for U.S. participation in the International Indian Ocean Expedition which has been assigned to the NSF? How are the NSF's coordinating functions with respect to the Indian Ocean Expedition reconciled with those of the Interagency Committee on Oceanography for coordinating the entire Federal oceanographic effort?

9. I am not sufficiently familiar with this question to reply.

10. What are your views on the establishment of international science centers and cooperative programs to spread the cost of expensive machines and devices? Could basic research at these centers retain its link with the education function in the absence of immediate proximity to a university?

10. I believe that international science in which the United States is a participant should be on the theoretical side, such as scientific economics and sociology which involve the use of large computers, certain parts of biological research which require large animal colonies and large computing facilities for unraveling complex biological structures. The members of these centers should reside for limited times and return to their respective countries and respective institutions and thus further the educational functions within their own countries. The proximity to a university is very useful in maintaining a proper and intellectual level and atmosphere.

11. In view of your public statements about how science can contribute to human welfare, do you believe any additional steps are necessary, or programs should be initiated, by the Foundation to accelerate the application of scientific discoveries?

11. I have no suggestion at the present time with regard to any specific program to be initiated. I will be very much interested if the Foundation together with HEW were to consider the support of educational programs to close the gap between the "two cultures" so as to make science a more central and important part of all education and to broaden the education of the scientists to include history, philosophy, sociology, ethics, and application of scientific advance, as well as the long-term political implications.

12. What should the Foundation be doing toward furthering public understanding and interest in science so that the layman will be better able to live in a scientific age?

12. See 11.

13. In fields of basic research such as high-energy physics, where increasingly large and expensive equipment and laboratories are required, what would you think of a national policy to assign responsibility for financing such installations to the Foundation?

13. This question is a political one. To my mind it resolves to the question, which agency is trusted by the Congress to do the most effective job where national expenditure is concerned? If the Foundation achieves such a respect and trust it would be the natural vehicle for such support.

14. Given the leveling off of budgets for the departments and agencies which have supported most of the research in physical sciences in the past, do you see a dropping off in the need for graduate students trained in the physical sciences?

14. No. The colleges, universities, and secondary schools are very poorly supplied with properly trained teachers in the physical sciences. With increasing enrollments these institutions could use several times the available supply. This answer does not begin to touch on the expanding need of ever-more-sophisticated industry.

15. Should NSF engage in a program of up-dating the science education of U.S. scientists who have been out of the country on assignment for a significant length of time?

15. It would be a great help if the National Science Foundation could supply some fellowship support or grant which would allow the person concerned a period of time to make up for scientific retardation incurred as a result of foreign service.

16. Should Congress authorize increased opportunities for exchange of scientists with other countries?

16. Yes. Because of the high cost of living in the United States it is very often necessary to supplement the income of a visiting foreign scientist. Likewise, an American scientist who goes abroad finds it difficult to get along on salaries prevailing in those countries. In each case, financial aid to proper candidates would make the exchange more effective from the scientific, political, and cultural points of view.

Response by Hon. Francis Keppel, Commissioner of Education, to Questions of the Subcommittee on Science, Research, and Development

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1. Supplementing your testimony of July 13, what are your agency's long-range plans for the support of science education? How were these plans developed and how are they kept to date?

1. Office of Education plans for the support of science education are integrated into our plans for supporting the educational system overall. Science as such is not emphasized over other subject fields in recent legislation, although there is some legislation, notably Science Youth Clubs, which is directed to the end of science education. Science activities will doubtless receive considerable attention in the operational programs. One of the possible uses of title III of Public Law 89–10, for example, might be the provision of special science courses for the academically talented where such courses were not currently available or the provision of mobile science laboratories for the use of rural students and teachers. Curriculum improvement activities directed to the sciences will continue and are expected to increase rather dramatically along with such activities in other subject fields, all as a result of the recent amendments to the Cooperative Research Act and the additional funds that will become available for the support of activities under that act. Title III of the National Defense Education Act will continue to support the purchase of equipment and nonconsumable materials for science education.

2. Your statement covered rather fully the overall coordination that exists between your office and the National Science Foundation. What coordination is there between your office and the science education programs of the mission-oriented agencies such as NASA?

2. Coordination between OE and other Federal agencies that support research and education in the sciences takes place in much the same way that OE–NSF coordination is achieved. There has been a longstanding informal group of Federal agency heads concerned with research and education programs, who have met from time to time to discuss common problems and policy directions. Dr. Seaborg, Mr. Webb, representatives of the National Institutes of Health, and other mission-oriented supporters of research and education, as well as the Director of NSF are members of this group. This informal coordination at the top will be further strengthened when the Federal Interagency Committee on Education is fully activated. (We are now proceeding to recruit staff to perform secretariat functions for this Committee.)

Below the agency-head level, the same committees that I described as assisting OE and NSF to coordinate their interrelated functions operate in a similar fashion with other Federal agencies as well. Thus the ad hoc committee to assist coordination in the various agency's

programs with respect to graduate education facilities includes representatives from NASA, NIH, AEC, as well as representatives from NSF. The same is true for a longstanding informal committee of representatives of agencies with graduate fellowship and trainee programs in the sciences: representatives of the programs whose interests are mission oriented exchange information views with agencies whose interests are science and education, per se, or endeavor to make programs as complementary and reinforcing as possible.

But the continuing day-to-day contact and cooperation between operating people of the various agencies with interrelated programs is still the most important way to achieve the greatest degree of coordination and reinforcement of programs between OE and the agencies with mission-oriented education concerns. Let me give some examples of how OE science education specialists, and people in the NASA education programs divisions have worked together to carry out projects of great significance to schools, and which neither could have done so well without the help, know-how, and funds from the other.

Early in 1961, NASA asked OE to help them in identifying ways to maximize the impact of NASA funds available for improving science education at elementary and secondary levels, as well as increasing the impact of NASA spacemobile services to schools. Consultation and cooperation at working levels have been continuous ever since. The two agencies worked out many joint projects, several of which have been especially significant, and have extended to involve other agencies. Let me cite two or three examples:

(1) Maine project: Office of Education specialists, in cooperation with the Maine State Department of Education, assisted a Maine school district in assessing its science instruction and in planning a self-improvement program to meet the needs of inadequate teacher training in science. The OE specialists then cooperated with NASA educational specialists in extending the single district experiment, and planned a statewide pilot instructional effort, patterned after the method of inservice education developed by the aforementioned school district. Together, NASA and OE assisted the State of Maine to plan for the evaluation of the project, and area evaluations have been carried out. Through the continued joint efforts of the OE specialists, Maine Department of Education personnel, and NASA representatives, a plan for dissemination of information about this inservice teacher evaluation program is underway. NASA will soon publish a report called "The Maine Story," which has been written by an OE specialist. Plans for distribution include all State departments of education and teacher training institutions.

(2) In June 1964, NASA, with the cooperation of OE, sponsored a national conference for State science supervisors, NASA educational personnel, and one of the AAAS science education subcommittees. Purposes of the conference include further exploration of the role of science education, particularly as it relates to the Nation's space effort, development of plans for implementation of science instruction, and provision of opportunities for the science educators representing various geographic and governing units to work together on specific problems. Proceedings were published and serve as excellent reference material.

(3) NASA is one of numerous Government agencies which has been involved in OE-sponsored research on educational research conference exhibits, and is a member of an informal interagency committee to improve the educational quality of exhibits in science, social science, arts, and other fields of knowledge. The purpose of these research conferences, and for the committee is to provide exchange of information and to coordinate research endeavors in the exhibit field, which is becoming an increasingly important aspect of education in the sciences, social sciences, and the arts.

3. What State, private, and foundation support for curriculum improvement is available today?

3. Very little support is currently available from State sources for the support of curriculum improvement. Private sources, including several foundations, have devoted some of their funds to this activity. The foundations have played their traditionally significant role as "pump primers." The Carnegie Corp., for example, began the funding of Prof. Max Beberman's mathematical project, the support of which his since been taken over by the National Science Foundation. Carnegie has continued its interest in the curriculum area with support to Harvard's Project Physics in its initial stages, a project which is currently being supported by the Office of Education and is soon to be jointly funded by the Office and NSF. The Kettering Foundation and the Sloan Foundation have also become involved to an increasing extent in this kind of activity. Probably the major foundation support for curriculum improvement has come from the Ford Foundation which has assisted Educational Services, Inc., in its social sciences program and awarded a series of grants under their small school improvement project, many of which have gone for curriculum improvement.

*4. You testified that "coordination of Federal activities in support of curriculum improvement is necessary, to assure the continued existence of alternative choices for local policy planners * * *."*

(a) Do you consider this to be the responsibility of the Office of Education? If not, whose responsibility is it?

4. (a) We take coordination of curriculum improvement activities to be a responsibility of any agency engaged in them, and since we have a strong commitment in this area, both in terms of resolve and in terms of funds, we feel a need and recognize a responsibility to perform this kind of function. That does not mean, however, that the Office of Education is the only agency which ought actively to seek to coordinate its activities. We would argue, in fact, that any Federal agency engaged in curriculum improvement ought to coordinate those activities with other agencies so engaged.

(b) Is it statutory or voluntary?

(b) Coordination of this sort is not statutory.

(c) In the field of science, does the coordinating responsibility belong to NSF?

(c) The coordinating responsibility could be met in the sciences by the National Science Foundation, but we are prepared to assist if and when such assistance seems necessary or desirable.

(d) Are private programs in curriculum improvement a significant factor?

(d) Private programs in curriculum improvement have been a significant factor in the past and are likely to be in the future. The foun-

dations in particular are in a position to play a role here of great importance. While it is true that NSF and OE have supported and presumably will continue to support large-scale projects in curriculum development, often the beginning efforts are more appropriately stimulated by funds from private sources.

5. Is sufficient support being given to the social sciences by NSF and other Federal agencies?

5. It has become increasingly clear to all Americans—to scientists and educators, to those concerned with the problems of government at Federal, State, and local levels, to businessmen, and to parents and citizens—that the support of social science research must be increased if we are to find answers to and provide solutions for our accumulating and pressing social problems.

The calls to increase and apply our social science knowledge come from every quarter: from those attempting to bring about full employment and flexible labor force, from those trying to solve the problems of our bulging cities and withering rural areas, from those trying to improve the organization of Government services and to increase productivity and creativity of private enterprise; from those responsible for protecting the mental and physical health of the Nation, and last but not least from those trying to improve our educational system. For educational research and development leans heavily on knowledge in the various social sciences, in economics, sociology, psychology, and combined and interdisciplinary fields as these disciplines are related to solutions to problems of educational content, methods, materials, organization, and administration.

Since education R. & D. is an area of research for which OE is primarily responsible, I think it is relevant to point out that it is in fact one of the areas of applied social science and hence dependent on the state of knowledge in many of the basic social science disciplines.

The facts about Federal funds for social science research seem to be these:

(1) In 1964, within total Federal R. & D.—$14.9 billion. All agencies spent about $79.4 million on basic research in the social sciences—psychology, sociology, economics, geography, political science, etc.

(2) When educational research is added to expenditures for basic social science research, the amount totals $111.2 million.

(3) When federally supported expenditures for education carried on by educational institutions in the social sciences are added to research, the grand total, including fellowships, traineeships, training of Federal employees, institutional grants for basic social sciences and various social science applied and combined fields such as foreign area studies comes to $192.7 million in 1964. (See table entitled "Federal Funds for Education in the Social Sciences".)

Federal funds for education in the social sciences, fiscal years 1961, 1962, 1963, and 1964 [1]

[Amounts in thousands]

Field of study and program	1961	1962	1963	1964
Grand total	$160,197	$159,832	$163,616	$192,711
Psychological sciences, total	19,203	23,958	28,774	34,738
Educational psychology	309	674	797	967
Graduate and postdoctoral	292	582	789	951
Graduate fellowships, OE	246	307	332	437
Fellowships, NIH	0	13	12	13
Training grants, NIH	0	262	421	477
Visiting scientist program, NSF	46	0	24	24
Combined higher education	17	92	8	16
Training grants, NIH	0	80	0	0
Vocational rehabilitation program, VA	17	12	8	16
Social psychology	2,786	4,136	4,741	4,844
Research	1,008	2,127	2,522	2,984
Research, development, test, and evaluation, DOD	337	1,121	1,121	1,559
Basic research grants	771	1,006	1,330	1,350
Facilities grants	0	0	71	75
Graduate and postdoctoral	212	762	1,388	1,234
Fellowships, NIH	0	262	414	157
Research career awards, NIH	0	30	15	22
Research grants, EEP, State	62	67	85	85
Training grants, NIH	0	265	681	771
Training grants in behavioral sciences, Commerce	0	0	0	6
University study grants, EEP, State	94	138	175	175
Visiting scientist program, NSF	56	0	18	18
Combined higher education	1,564	1,246	828	621
Educational travel for foreign students, EEP, State	1	3	3	3
Advisory service and technical training, EEP, State	22	6	7	7
University teaching, EEP, State	100	76	96	96
Veterans educational assistance, VA	1,433	973	664	455
Course content improvement, NSF	0	0	29	20
Supplementary teaching aids, NSF	8	188	29	40
Federal employee training	2	1	3	5
Navy short course program, DOD	1	0	0	2
Employee training, Justice	1	1	3	3
Clinical psychology	7	4,634	5,573	6,298
Graduate and postdoctoral	7	4,462	5,573	6,298
Fellowships, NIH	0	175	375	404
Research cancer awards, NIH	0	63	42	59
Research grants, EEP, State	7	17	21	21
Traineeships, NIH	0	73	22	24
Training grants, NIH	0	4,134	5,113	5,790
Combined higher education	0	172	0	0
Training grants, NIH	0	172	0	0

See footnotes at end of table, p. 1218.

Federal funds for education in the social sciences, fiscal years 1961, 1962, 1963, and 1964 [1]—Continued

[Amounts in thousands]

Field of study and program	1961	1962	1963	1964
Psychology, n.e.c.	$16,101	$14,514	$17,663	$22,629
Research	4,246	5,650	6,009	8,850
Research, development, test, and evaluation, DOD	1,393	2,422	2,015	3,500
Research and demonstration in vocational rehabilitation, VRA	688	794	1,008	1,250
Basic research grants, NSF	2,165	2,434	2,986	4,100
Graduate and postdoctoral	8,802	5,284	7,783	9,405
Fellowships, NIH	0	1,885	2,531	2,962
Research career awards, NIH	0	727	1,576	2,201
Traineeships, NIH	0	39	9	16
Training grants, NIH	7,567	1,021	1,596	1,835
Graduate fellowships, OE	455	471	623	811
Howard University, DHEW	3	5	5	6
Training at St. Elizabeths, DHEW	43	83	104	68
Vocational rehabilitation training grants, VRA	137	181	312	394
Traineeships of Bureau of Prisons, Justice	12	21	25	41
Fellowships, NSF	399	669	814	875
Institutes, NSF	77	144	116	104
Research participation, NSF	109	38	72	78
Undergraduate	136	501	755	950
Training grants, NIH	0	0	26	0
Howard University, DHEW	35	65	71	80
Science education program, NSF	101	290	339	339
Instructional equipment, NSF	0	146	319	531
Combined higher education	31	200	25	100
Faculty support, NSF	31	200	25	100
Federal employee training	2,876	2,879	3,091	3,324
Training in allied medical sciences, VA	2,876	2,879	3,091	3,324
Social sciences, total	27,553	27,539	29,386	31,421
Economics	390	3,004	1,737	2,114
Research	328	2,759	1,305	1,631
Economic research	203	81	149	159
Research and technical assistance for farmers, Agriculture	28	11	16	25
Area redevelopment research	0	385	1,065	1,300
Fellowships in fishery research, Interior	0	0	5	10
AID research projects, State	0	2,166	10	0
Science organization and management program	0	0	49	0
Universities studies program	97	116	11	137
Graduate and postdoctoral	62	245	430	480
Fellowships, NSF	62	245	428	468
Research participation, NSF	0	0	2	6
Training grants in behavioral sciences, Commerce	0	0	0	6
Federal employee training	0	0	2	3
Employee training, Commerce	0	0	1	2
Employee training, Treasury	0	0	1	1
Area studies	100	52	62	1,535
Graduate and postdoctoral	22	5	31	35
Fellowships, NSF	22	5	31	35
Combined higher education	78	47	31	1,500
Information and cultural programs overseas, State	78	47	31	30
Foreign language and area studies, OE	0	0	0	1,470

See footnotes at end of table, p. 1218.

Federal funds for education in the social sciences, fiscal years 1961, 1962, 1963, and 1964 [1]—Continued

[Amounts in thousands]

Field of study and program	1961	1962	1963	1964
Sociology	$57	$152	$246	$358
Research	0	54	105	190
Social security program studies	0	54	105	190
Graduate and postdoctoral	57	98	141	168
Advanced science seminars, NSF	0	0	0	18
Fellowships, NSF	57	98	136	144
Research participation, NSF	0	0	5	6
Anthropology	456	376	808	1,433
Research	0	0	88	90
Research facilities grants	0	0	88	90
Graduate and postdoctoral	150	273	342	285
Fellowships, NSF	150	273	271	285
Science education developmental projects, NSF	0	0	71	0
Undergraduate	0	0	13	13
Science education program, NSF	0	0	13	13
Combined higher education	306	103	365	1,045
Course content improvement studies, NSF	0	74	0	610
Supplementary teaching aids, NSF	306	29	365	435
Social sciences, NEC	26,550	23,955	26,533	25,981
Research	3,313	7,111	8,679	8,132
State agricultural experiment stations, Agriculture	500	500	500	500
Cuban refugee program, OE	49	112	20	82
Research and demonstration grants, VRA	299	478	329	500
Cooperative research and demonstration grants, WA	347	698	1,064	0
Industrial economic studies	21	25	29	50
Basic research grants	2,097	5,298	6,737	7,000
Graduate and postdoctoral	14,963	9,906	11,101	11,695
Fellowships, NIH	830	323	784	849
Research cancer awards, NIH	0	0	88	123
Training grants, NIH	6,612	1,186	1,628	1,839
Graduate fellowships, OE	5,400	5,749	5,243	5,631
Howard University, DHEW	9	11	19	21
Research grants, EEP, State	390	459	583	583
Teaching and teacher training grants, EEP, State	449	521	661	661
University study grants, EEP, State	986	1,139	1,446	1,446
Advanced science seminars, NSF	0	58	218	104
Fellowships, NSF	71	185	164	174
International science education activities, NSF	4	0	0	0
Institutes, NSF	191	235	221	229
Summer conferences, NSF	0	19	0	0
Visiting scientist program, NSF	21	21	46	35
Undergraduate	231	401	649	747
Howard University, DHEW	177	268	355	390
Science education program, NSF	54	133	240	240
Instructional scientific equipment, NSF	0	0	54	117
Combined higher education	8,043	6,537	6,102	5,407
Advisory services and technical training, EEP, State	157	303	384	384
Educational travel for foreign students, EEP, State	88	94	119	119
Observation and consultation, EEP, State	1,126	1,222	1,552	1,552
University teaching, EEP, State	823	1,135	1,441	1,441
Advanced science seminars, NSF	0	0	0	8
Course content improvement, NSF	0	0	57	50
Veterans training, VA	5,849	3,783	2,549	1,853
Federal employee training	0	0	2	0
Training of employees, FCC	0	0	2	0
Applied social sciences, total	67,977	62,419	55,518	54,054

See footnotes at end of table, p. 1218.

Federal funds for education in the social sciences, fiscal years 1961, 1962, 1963, and 1964 [1]—Continued

[Amounts in thousands]

Field of study and program	1961	1962	1963	1964
Business and public administration	$2,638	$4,061	$4,977	$5,159
Research	0	598	370	0
AID research projects, State	0	598	355	0
Science organization management program	0	0	15	0
Combined higher education	2,414	3,276	4,414	4,963
Howard University, DHEW	27	32	50	51
AID participant training	2,387	3,244	4,364	4,912
Federal employee training	224	177	193	196
Employee training, Commerce	4	3	11	15
Employee training, DOD	1	7	2	2
A.F. resident schools, DOD	132	0	0	0
Navy short course program, DOD	14	27	32	35
Employee training, SSA	0	5	6	11
Employee training, Interior	6	15	19	21
Employee training, Justice	11	25	26	30
Employee training, Treasury	3	1	19	18
Staff development, BOB	2	5	6	5
Employee training, HHFA	9	39	29	0
Employee training, ICC	1	2	2	0
Employee training, SBA	22	23	17	25
Employee training, TVA	1	4	2	3
Training in allied medical sciences, VA	18	21	22	31
Social work	4,800	6,039	8,613	10,525
Graduate and postdoctoral	4,172	5,347	7,801	9,581
Howard University, DHEW	76	107	158	175
Training grants, VRA	2,191	2,853	3,927	4,756
Education of State child welfare personnel, WA	1,420	1,762	2,217	0
Child welfare training grants, WA	0	0	199	1,750
Training State public assistance personnel, WA	485	625	1,300	2,900
Combined higher education	17	16	23	21
Traineeships of Bureau of Prisons, Justice	17	16	23	21
Federal employee training	611	676	789	923
Training in allied medical sciences, VA	611	676	789	923
Other	1,010	1,025	1,379	1,350
Research	1,010	1,025	1,379	1,350
Urban studies and housing research	0	14	123	0
Documentation research program	1,010	1,011	1,256	1,350
Library science	12	52	76	60
Graduate and postdoctoral	0	28	28	0
Research libraries, NSF	0	28	28	0
Federal employee training	12	24	48	60
Training in allied medical sciences, VA	12	24	48	60
Applied social sciences, NEC	59,517	51,252	40,473	36,960
Research	1,010	1,025	1,379	1,350
Urban studies and housing research	0	14	123	0
Documentation research program	1,010	1,011	1,256	1,350

See footnotes at end of table, p. 1218.

Federal funds for education in the social sciences, fiscal years 1961, 1962, 1963, and 1964 [1]—Continued

[Amounts in thousands]

Field of study and program	1961	1962	1963	1964
Applied social sciences, NEC—Continued				
Graduate and postdoctoral	$1,055	$6,726	$8,735	$9,825
Fellowships, NIH	0	22	71	76
Training grants, NIH	0	5,507	7,123	8,067
Howard University, DHEW	82	96	130	145
Traineeships of Bureau of Prisons, Justice	1	2	3	7
Research grants, EEP, State	108	84	106	106
Teaching and teacher training grants, EEP, State	87	108	137	137
University study grants, EEP, State	777	905	1,148	1,148
Fellowships, NSF	0	2	17	19
Science education developmental projects, NSF	0	0	0	120
Combined higher education	57,426	43,466	30,329	25,748
AID participant training program, State	14,294	15,167	10,271	10,407
Advisory services and technical training, EEP, State	1,614	1,795	2,280	2,280
Educational travel for foreign students, EEP, State	148	158	200	200
Observation and consultation, EEP, State	1,415	1,667	2,117	2,117
University teaching, EEP, State	224	427	542	542
Documentation research program, NSF	0	0	224	50
Science education developmental projects, NSF	0	0	0	46
Veterans education, VA	39,731	24,252	14,695	10,106
Federal employee training	26	35	30	37
Employee training, Justice	2	3	5	8
Employee training in bank examining	18	20	21	26
Employee training, Farm Credit Union	2	10	3	3
Employee training, Railroad Retirement Board	1	1	0	0
Employee training at St. Elizabeths, DHEW	3	1	1	0
Education, total	42,108	41,272	40,025	54,847
Research	9,159	12,598	14,598	20,284
Dissemination of information on new media, OE	1,320	2,215	3,171	3,200
Educational improvement for the handicapped, OE	0	0	0	1,000
Educational media research, OE	3,409	2,496	1,770	1,800
Educational research (foreign currency), OE	0	0	34	514
AID research projects, State	0	610	0	0
Course content improvement, NSF [2]	4,430	7,277	9,623	13,770
Graduate and postdoctoral	10,877	13,153	14,075	21,774
Fellowships, NIH	143	0	0	0
Counseling and guidance institutes, OE	6,500	7,062	7,250	7,250
Educational improvement for the handicapped, OE	951	2,429	2,455	9,929
Graduate fellowships, OE	1,140	1,470	1,588	1,752
Correctional education demonstration projects	0	0	0	61
Research grants, EEP, State	24	77	98	98
Teacher and teacher training grants, EEP, State	1,857	1,851	2,350	2,350
University study, grants, EEP, State	262	264	334	334
Undergraduate	111	101	147	2,596
Educational improvement for the handicapped, OE	0	0	0	2,416
Howard University, DHEW	111	101	92	105
Education in Trust Territory of the Pacific, Int	0	0	55	75
Combined higher education	21,961	15,418	11,204	10,191
Educational improvement for the handicapped, OE	42	63	32	683
Advisory services and technical training, EEP, State	368	475	604	604
Educational travel for foreign students, EEP, State	6	96	122	122
Observation and consultation, EEP, State	386	437	555	555
University teaching, EEP, State	2	2	3	3
Veterans education, VA	21,157	14,345	9,888	8,224

See footnotes at end of table, p. 1218.

Federal funds for education in the social sciences, fiscal years 1961, 1962, 1963, and 1964 [1]—Continued

[Amounts in thousands]

Field of study and program	1961	1962	1963	1964
Applied social sciences, NEC—Continued				
Federal employee training	0	$2	$1	$2
Employee training, Justice	0	0	0	1
Employee training, GSA	0	2	1	1
Combined fields, total	$3, 356	4, 644	9, 913	17, 651
Research	3, 356	4, 644	9, 913	17, 651
Cooperative educational research	3, 356	4, 644	6, 985	11, 500
Manpower development and training	0		2, 928	61, 51

[1] Includes programs identified by field of study in survey of "Federal Funds for Education and Related Activities." Some programs, for example, Department of Defense R. & D. funds in universities, were not reported by specific fields of study and data are not available and therefore not included in this tabulation.

[2] Grants in social science fields are included in other categories.

(4) This is a pretty small slice of total Federal expenditures of Federal funds for research, education, and training which totaled $6 billion in 1964.

While Federal expenditures in research, education, and training in the social sciences increased from $160.2 to $192.7 million, I think there is substantial agreement that this increased Federal support for research, education, and training in the social sciences must be accelerated. Increases achieved so far create a firm base for future expansion of social science research and education. Through research grants, graduate fellowships and traineeships, we have substantially increased the number of competent researchers and teachers. We have begun the job of examining the state of teaching social science in our schools and colleges.

I do not think we can afford to be complacent about our progress however. We will be pushed by events—by crises if you will—to find answers to situations for which undone social science research should have supplied us with answers. I think the present efforts to effect desegregation of our schools and cities and to find cures for chronic poverty are examples of this.

It is encouraging, however, to look at the rate of increase in expenditures for social science research and education by Federal agencies. Dr. Haworth has provided figures showing that NSF support for basic research in the social sciences is increasing faster than research support in any other field. It has risen from a total of $4 million (including psychology) in 1960, to $16.3 million in 1964, a fourfold increase. During the same period 1960–64, OE expenditures for educational R. & D. have increased from $10.8 million to $21.5 million.

6. Federal support of quality manpower development is concentrated in postgraduate education. Nevertheless, high-quality graduate students come only via undergraduate production.

(a) At what grade level in our modern educational structure does a student chart his course toward science, engineering, social studies or the arts?

6. (*a*) The college years, since this is where conscious and deliberate career choices in the areas of science, engineering, social studies, or the arts are most frequently made. To say this, however, ignores the vital role of elementary and secondary education to create the predispositions or capabilities on the basis of which the in-college choices can be made. The answer also ignores the frequent changes in career choice that do occur after college. The point at which the choice is made, then, may be worthy of some attention, but other levels of the educational system may be of equal significance in setting the conditions for that choice.

(*b*) *Should the National Science Foundation exert influence by the investment of support at this level?*

(*b*) The answer to this question, of course, rests on the reply to (*a*) above. Clearly attention should be paid to all levels of the educational system, not just the one where the choice happens to be finally made. The Foundation is in effect doing this by its curriculum programs in elementary and secondary education and at the undergraduate level, and through its support of fellowship and facilities programs.

(*c*) *Do you believe that fellowship or institutional support of pregraduate education should be proportionately increased or decreased?*

(*c*) Fellowship and institutional support of undergraduate education should be substantially increased. Such support, however, ought not to be categorical, particularly in relation to fellowships. By offering noncategorical fellowships, doors for future choices can continue to be kept open for individual students. In addition, title III of the new Higher Education bill will materially aid developing institutions through the provision of teaching fellowships and authorization for the support of cooperative agreements to strengthen undergraduate programs.

7. *With the great emphasis being given to "new starts" in education, are our educational programs overlooking the retraining of experienced scientists and engineers whose specialties have become obsolete?*

7. The direct answer to the question is a flat "Yes." Given the scientific, organizational, economic, and occupational dynamics of modern life, the need for occupational updating and retraining is now a universal need. It is a need, however, which is not now being met systematically by any major program at the State or Federal level. Scientists and engineers are by no means special cases in this respect. They are served just as well as other occupational categories, which is very little at best. An exception is the recent Sloan Foundation grant to MIT to develop materials and programs designed for engineering retraining. The medical profession has also turned its attention to this problem delivering an extensive report with recommendations some 3 years ago. By and large, however, we are still pretty close to ground zero in this important area.

Part of the problem stems from the absence of reliable data on a variety of measures associated with this kind of activity. Estimates and projections of the future size of the retraining clientele and costs of such services cannot be made until we develop data on present enrollments and sources of funding of such educational services, including the share of costs borne by employers in relation to total overhead and operating costs. We also require data on expenditures by

individuals at various occupational and income levels for their own retraining and updating, including out-of-pocket costs and foregone earnings. We need more information on present public funding at the State level or in institutions of higher education in support of retraining activities, including unemployment insurance, and more complete information on what Foundations are doing in this area.

I might add that the administration Higher Educeation bill contained some thrust in the direction of retraining and continuing education in the original title I, but as the bill came through committee and passed the House, the purpose had shifted somewhat to a more directed concern over the problems brought about by increasing urbanization and the contributions of institutions of higher education to the solution of those problems. Some of the original thrust has been restored to the bill in the Senate, after being removed from the House version. Title I as it now stands in the Senate will enable us to make a start toward meeting this growing problem.

8. From the standpoint of maintaining excellent teachers, how effective is the retraining of teachers who have been in the field for a number of years, compared with continuing the training of students who have just finished with their graduate or postgraduate degrees?

8. Comparison between the retraining of teachers who have been in the field for a number of years to continuing the training of students who have just finished their graduate degrees tends to be misleading. First, we cannot afford an either-or choice. We need more excellent teachers than either one of the two techniques alone can provide us. Second, individual teachers will always require both methods to insure the continuation of their excellence. The production of excellent teachers require high quality initial educational and training experiences, but if they are to continue performing at high levels, teachers will need frequent refresher courses to keep up with new developments in educational research and curriculum development at the elementary, secondary, and higher education levels. It must also be said, however, that teachers who are trained without the recognition that they will need future retraining are in effect being done a disservice. The effective utilization of retraining techniques rests on preconditioning the teacher to an understanding of their value and importance. The absence, in many cases, of this kind of preconditioning may be counted as one of the continuing weaknesses of teacher-training programs as they now exist.

9. Our support of universities and colleges appears to be heavily weighted on the side of research, as distinguished from the education of students or the training of teachers.

(a) Is this deliberate national policy?

(b) Which do you consider more important—the promotion of science research or the advancement of science education?

(c) Do you see any danger of turning our colleges—that is, their science and engineering departments—into great research laboratories?

9. The distinction between Federal support to higher education institutions for basic research and for education of students is to a considerable extent an artificial one. It is undesirable, if not impossible, to carry on good graduate education in any field today away from a research environment. Unless the faculty are involved in

research and the students themselves carry on research, the education they receive is likely to be marginal.

I do think there is a problem if research and teaching become organizationally separate functions in our higher education institutions, or if research remains as concentrated as it is in a relatively few major universities. To the degree that researchers do only research in separately organized research units on the campus, and teachers do only teaching, or some institutions do little or no research, we are creating barriers between the production of new knowledge and its dissemination. Such barriers automatically create the probability of obsolescence among faculty members who are not involved in research.

Our statistics on research and teaching manpower in universities and colleges are expressed in full-time equivalents of individuals doing each function. This tends to cloak the degree to which the divorce between teaching and research is happening. To the degree that it has happened or is happening (and I think there is evidence that it has happened in the weaker colleges—the ones that have received little in the way of research grants, have inadequate research facilities or resources for updating faculty) we must take steps to remedy the situation.

Both OE and NSF are working on complementary lines of remedial and preventive action. NSF has established programs of institutional science development grants, teaching-oriented research grants, research participation arrangements for college faculty in major university research centers. OE is planning to expand its institutes programs to include college faculty in all fields, and to involve college faculty—who are, after all, the teachers of most of our potential elementary and secondary teachers—in the continuing process of updating through the activities of the new educational laboratories soon to be created under the amended Cooperative Research Act. The mission-oriented agencies research programs are also contributing to preventative and remedial action by opening laboratories to university and college faculty as well as graduate and undergraduate students, through the establishment of research fellowships, traineeships, and assistantships.

Given present awareness of the dangers of letting a gap grow between research and teaching in colleges and universities, I think the possibility of turning our higher education institutions into great research laboratories to the detriment of teaching will be avoided. The remedial and preventive measures indicated above will have to be increased, however, if we are to succeed.

10. What rate of growth in support for facilities and for students is needed to meet the needs of graduate student enrollments? What does a 15-percent increase per year, which has been suggested for Federal support of academic research, imply for scientific manpower which has been increasing at about 6 percent per year?

10. The primary determinant of the need for more higher education academic facilities lies in the challenge of increasing enrollments. Current projections indicate that graduate enrollment is expected to rise from approximately 577,000 in 1965 to 834,000 in 1970 and to 1,066,000 in 1975. These are conservative estimates which do not take into account the stimulative effects of new programs such as the student loan program or the significant expansion of the graduate fellowship program. It has been estimated that merely to meet the graduate

program needs for new and enlarged facilities covered by the graduate enrollment increase would require a total investment of approximately \$129.0 million in 1966, \$196.0 million in 1967, and \$290.0 million in 1968. To this should be added \$61.0 million for 1966, \$66.8 million for 1967 and \$68.7 million for 1968 for the cost of future replacement, rehabilitation, and modernization of current facilities. In addition, the backlog of obsolete and substandard facilities was estimated to be approximately 90 million square feet of graduate and undergraduate instructional facilities in 1961. The cost of the graduate portion of the backlog is estimated at \$233 million. These figures give some measure of the support for facilities needed to meet graduate student enrollments.

The availability of facilities is obviously only part of the problem of meeting the needs of increased graduate student enrollments. Another important factor is the financial ability of students to attend colleges and universities. During fiscal 1963, which is the latest year for which we have comprehensive data, Federal support to college and university students amounted to \$225 million for 232,000 students in 802 universities. These included all but three of the Nation's top 100 institutions of higher learning as rated on the basis of Federal research expenditures. Federal graduate student support for this period amounted to \$153 million for 102,000 students. Since graduate enrollment was approximately 475,000 in 1963, Federal support was extended to slightly more than one-fifth of these students. (This is a rough approximation since the number of students receiving support includes some duplication where students received assistance from more than one Federal source.) If this same ratio is maintained, this would mean an additional 10,000 graduate students to be supported in 1966 and an additional 14,400 graduate students to be supported in 1967 based on graduate student enrollment estimates. Using the title IV, NDEA, graduate fellowship average of \$5,000 per year per student as a basis, this would mean an added \$50 million for 1966 and \$72 million for 1967. This is based upon the present doctoral level fellowship program. A new Teaching Professions Act of 1965 has been proposed to meet the master's degree needs of elementary and secondary teachers. One estimate has placed the cost of this graduate fellowship program at approximately \$40 million for 4,500 fellowships in 1966, and approximately \$115 million for 4,500 continuing fellowships plus an additional 10,000 fellowships in 1967. These figures given both a rough index of support needed to meet present graduate student enrollment projections with present programs as well as some indication of the additional support required for the new program.

A 15-percent increase per year in Federal support for academic research would appear to be a reasonable rate of increase—at least for the immediate future. You are already aware of the efforts being made to determine more accurately the optimum rate of change of Federal support in this area. From the testimony of Dr. Haworth, Dr. Hornig, and others, you know that the 15-percent figure takes into account increased costs of doing research as well as increasing numbers of graduate students. Because of this, it is not clear to us that this rate of increase of academic research support will lead to additional strains on our scientific manpower supply that will not exist

in any case if we continue to provide an adequate rate of increase in science graduate enrollments.

In 1962 about 350,000 scientists were employed in the United States; by 1975 science manpower requirements may be near 650,000. In addition to the 300,000 increase in the number of scientists required for growth, another 100,000 will be needed to replace experienced scientists who die, retire, or leave the profession for some other reason. This expected growth will reflect the needs placed on technical manpower by the Nation's aerospace, health-related research, defense, technical assistance, and other programs. Broadly speaking, mathematics and physics will be among the fastest growing fields; the largest science fields—chemistry and the biological sciences—also will expand rapidly. Interdisciplinary areas, such as those found in oceanography, biophysics, and metallurgy, can be expected to expand greatly. Current levels of the training of chemists, physicists, and mathematicians are not expected to provide enough supply to meet anticipated future demands during the 1965–75 period. Relative to most other scientific and technological fields, the supply of biological scientists would be more likely to meet future requirements. An estimated 50,000 social scientists were working in 1962. Although they were in a variety of occupational fields, the majority of social scientists were employed by colleges and universities. The demand for social scientists will continue high throughout the 1965–75 period as college enrollments continue to increase. Growing numbers will also be needed by Government, industry, private foundations, and research organizations. Manpower requirements in the social sciences are expected to grow to nearly 90,000 in 1975. Approximately 55,000 new persons will have to enter the field in order to account for growth as well as replacement needs.

11. Do you think Federal support to higher education should extend to students interested in the management sciences, industrial engineering, and business administration as these relate to application of the results of scientific research? If so, is this responsibility suited for the National Science Foundation or for the Office of Education?

11. Federal support of the "management sciences" is very necessary, but should not be restricted to, or concentrated in any one agency of the Federal Government.

Historically, the management sciences grew out of the effort to advance the processes of decisionmaking and administration of research. Now, however, the management sciences, combining analytical approaches of both the natural and social sciences, together with techniques of quantitative measurement and applications of the computer to finding solutions to complex management problems through operations research, systems analysis, model building, et cetera, are becoming essential instruments for the efficiency of every large-scale undertaking, including Federal agencies, State, local governments, business concerns, and educational institutions and systems. Every Federal agency whose mission involves large-scale operations or the conduct or support of research must, therefore, be concerned with the research on, and the development of, management techniques that assure better management of its business. Thus, NSF, as well as other Federal agencies concerned with management of research in support

of their missions, have in varying extent conducted or supported research in the management sciences.

This is as it should be. One can argue that the level of support given to this field has been inadequate, but one cannot, I think, make the case for its concentration in a single agency.

Educators are becoming increasingly aware that the level of support to research in the management sciences as applied to education has been too low. Education has only begun to nibble at developing and using the management sciences to find solutions to the complex problems of running the huge establishments that our universities, and school systems have become. Research and application of the management sciences to education will be one of the areas where education R. & D. funds will be increasingly applied by the Office of Education, both through external research grants and contracts, and internal applications to the management of the Office itself.

The current development, for example, of a comprehensive, computerized educational data system by the Office of Education is a major step in application of the management sciences to education.

12. Will you discuss the activity to date and the plans for the Federal Interagency Committee on Education, particularly with respect to coordination of graduate student and institutional support programs of the various agencies, stipend standardization, allocation between fields of science, collection, and interpretation of statistics?

12. The Federal Interagency Committee on Education has held its initial meeting, at which the secretariat responsibility for the Committee support was lodged with the Office of Education. Under the new organization plan of the OE, this duty will be assumed by the Assistant Commissioner for Planning and Evaluation, who is now being recruited. The Office of Education hopes to have this position filled and the Committee backstopped in the matter of a few weeks. The purview of the Committee will include all the matters included in the question.

13. Have the cooperative fellowships and graduate traineeship programs succeeded in balancing the tendency for fellows to seek training only at a few top-rated schools? Or has this attempt at dispersal of support to more schools been diluted by other concentrating effects of Federal funding in institutions of higher learning—for example, by the concentration of research grants, research facilities, and the location of research centers? Has the number of centers of academic excellence grown?

13. I understand that NSF has submitted data to the subcommittee concerning the cooperative fellowship and graduate traineeship programs. These data show that the fellowships and traineeships in these programs have been distributed much more widely among the Nation's graduate schools than the regular NSF graduate fellowships. The cooperative fellowship program is being discontinued after fiscal year 1965, but the traineeship program is being expanded and will be supporting twice as many students as the regular fellowship program in fiscal year 1966. The tendency for fellows under the regular program to concentrate at top-rated institutions will thus be strongly counterbalanced by the policy of wide distribution of assistance under the traineeships program. An additional strong counterbalance is the National Defense Education Act, Title IV: Graduate Fellowship Pro-

gram, administered by the Office of Education, which has, since its establishment in 1959, given highest priority to assisting developing institutions and increasing the numbers of centers of academic excellence. One indication of the decreasing concentration of graduate education at the level of the doctorate is the fact that the percentage of the Nation's doctorates awarded by the Keniston-Berelson group of 12 top-rated institutions[1] has declined from 31.4 percent in 1959–60 to 29.8 percent in 1963–64. Another is that the number of institutions awarding 100 or more doctorates increased from 29 in 1959–60 to 43 in 1963–64.

14. With science education and basic research so intimately linked throughout the NSF program, what does this portend for the small college which is unable to support a vigorous R. & D. effort but still wishes to graduate high quality bachelors of science?

14. Our figures on the organization of research reveal a growing distance between undergraduate teaching and involvement in research. The linkage between science education and basic research throughout the NSF program means that small colleges unable to support a vigorous R. & D. effort have not been ordinarily able to look to the NSF program as a means of strengthening the competence of their scientific faculty.

The problem exists not merely because these colleges are excluded from the benefits of the program in some degree. It is also a concomitant of the direction of NSF funds to other, stronger academic centers which has tended to draw scientific competence away from the small college.

NSF is fully cognizant of this problem and its importance. It is adapting its programs insofar as it can within its legislative mandate to mitigate the problem. The problem will only be overcome by a concerted effort under which the programs of the NSF and OE are mutually adapted in the light of definitions of criteria and a classification of institutions agreed upon by both agencies.

There are several existing or developing programs in both agencies which are designed to attack this problem. NSF is expanding its program of research for small colleges, in effect attacking the problem head on. The Office of Education is approaching it directly by expanding institute programs for retraining college teachers and by providing assistance for cooperative graduate centers of excellence under title II of the Higher Education Facilities Act to provide for the development of programs beyond the capacity of individual institutions.

In addition, grants and loans under title I of the Higher Education Facilities Act are available for equipment and buildings for scientific instruction and research. Grants are approved under this title in accordance with criteria approved by State commissions. It has, however, been the policy of the Office of Education to encourage the commissions to develop standards which preserve the competitive position of the small colleges.

Title III of the proposed Higher Education Act of 1965 will also undoubtedly play a major role in strengthening both research and instruction in small colleges. The aid possible under this title not being limited categorically—for example, to facilities alone—can be directed

[1] Cf. Bernard Berelson, "Graduate Education in the United States," McGraw-Hill, 1960, pp. 124–128.

toward any of the particular weaknesses of a small college. Inter-institutional relationships will also be fundamental to this program as is also the case of the graduate centers of excellence under title II of the Higher Education Facilities Act. Although small colleges may not have the resources to undertake highly specialized research, they can through association, retraining, and exchange of faculty members come to have sufficient participation in or exposure to, research and new learning in order to maintain academic standards of excellence.

Finally, the national program of educational laboratories shortly to be announced by the Office of Education ought eventually to have some impact in this area. Curriculum improvement activities at the elementary and secondary level have now taken on the nature of a continuing activity, but at the college level we still have some distance to go before we can legitimately say we are meeting our full responsibility. The cooperative relationships that will be created in the conduct of the laboratory program between small and large institutions and between institutions of higher education and the schools as well as the direct improvement of undergraduate curriculum as part of the functions of these laboratories should also be of considerable significance in insuring the production of high quality bachelors of science.

15. Are the Foundation institutional grants consistent in policy and content with those of HEW, NASA, Department of Defense, and other Federal agencies? What is the general amount of private sector support in these same programs?

15. In our estimation this question is better answered by the Foundation than by USOE.

16. Exactly how do you make use of the Science Information Exchange?

16. The Office of Education makes use of Science Information Exchange in at least two ways. Under the cooperative research program and the research and demonstration program directed to the problems of handicapped children and youth by the Bureau of Research, principal investigators have been required to complete SIE abstract forms for inclusion in the SIE system of ongoing research. SIE has returned multiple copies of the forms to OE, the cooperative research program, and the research program for handicapped children and youth. The files of these forms have been consulted in answer to requests regarding particular projects. The abstracts have been forwarded to the requester for his information.

The second use that has been made of SIE is in connection with program planning activities. Since SIE keeps a record of all inquiries made, by asking them who has made requests for certain kinds of information it is possible to locate individuals and institutions who are working on problems of interest to the Office of Education. This knowledge has proved particularly valuable for the development and extension of new and existing programs.

17. Considering the pros and cons of diversity of support versus centralization in one agency, what would be the advantages and disadvantages of combining in one Federal department or agency all of the various educational and training programs relating to scientists and engineers?

17. The disadvantages of combining in one Federal department or agency all of the various educational and training programs relating to scientists and engineers would far outweigh the advantages of control, organizational visibility, and administrative simplicity. Many of the agencies in need of scientific and engineering manpower have specific missions to perform and require personnel trained to work in the areas of their responsibility. By administering their own programs of manpower, education, and training related to their specific needs these agencies can contribute directly to the conduct of the programs they are charged with by insuring a sufficient supply of adequately and appropriately trained manpower. The value of the separate agencies administering their own programs directed to the training of scientific and engineering personnel does not, however, detract from the need for a strong measure of coordination, a function which is now being met by the Office of Science and Technology.

18. In your opinion, what are the prospects of meeting the goals of the Gilliland report? If these goals seem unattainable by present efforts, what more might be done, and by whom?

18. The goals of the Gilliland report are the following:

(1) Increase the number of doctor's degrees awarded each year in engineering, mathematics, and physical sciences to reach 7,500 in 1970.

(2) Increase the number of students who complete a full year of graduate training in engineering, mathematics, and the physical sciences to reach 30,000 during 1970.

(3) Encourage the strengthening of existing centers of excellence in engineering, mathematics, and physical sciences and develop new centers of educational excellence.

(4) Promote wider geographic distribution of centers of educational excellence.

According to most recent trend projections, the number of doctor's degrees awarded in engineering, mathematics, and the physical sciences in 1970 will be 7,890 and the number of students completing master's degrees will be 38,550. Gilliland committee goals (1) and (2) should thus be exceeded. Evidence such as that set forth in answer to question 13 indicates that goals (3) and (4) are also being gradually achieved. In addition to the National Defense Education Act title IV fellowship program and the NSF traineeship program, progress toward goals (3) and (4) is being made under the Higher Education Facilities Act title II, graduate facilities program and the NSF science development program to assist developing centers of academic excellence.

19. The point has been brought during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. Specifically:

(a) What guidelines or criteria have been established by the Office of Education to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the agency's jurisdiction and, therefore, should, or should not, be supported by the Office of Education?

(b) If written criteria have been established, please submit a copy thereof to the committee.

19. The Office of Education research programs are directed to research, surveys, demonstrations, and dissemination in education. Frequently this means research in social science disciplines related to the field of education such as sociology, psychology, anthropology, and other social sciences. Because of the particular mission of the Office of Education research programs the problem of which agency should fund a given project comes up relatively infrequently. It occurs most often, however, in the area of curriculum development in some of the developmental grants to support conferences discussing educational research needs. Since all curriculum improvement activities are within the scope of the Office of Education research programs, decisions regarding proposals which might be funded also by NSF are made on an individual basis. Generally speaking, however, a proposal has been directed to NSF only when the Foundation had already had some funding experience with the program for which funds are being applied or where joint support is specifically requested. No written criteria have been established for determining whether or not a particular project was within our purview or that of NSF.

20. Further supplementing your testimony, what has happened to private sector support of science education in the face of increased Federal spending? In this connection, what proportions of graduate science students are self-supported or receive non-Federal fellowships? Is the Federal fellowship program adversely affecting the programs of private foundations because of more attractive terms?

20. The most recently completed study of stipends received by students for graduate study covering 37 fields including science and nonscience disciplines produced the following results. In science fields 70 percent of the graduate students had stipends of one kind or another. In nonscience fields 47 percent of the students had stipends. The students were asked to name the source of their support and reported for science that 38 percent had support from Federal sources and 62 percent had support from non-Federal sources. (These figures are open to considerable question, however. A later check revealed that in many cases students reported their institutions as the source of their stipends when in reality the stipend they were awarded was part of a Federal program of one kind or another.) In nonscience fields the study revealed that 10 percent of the students reported stipends from Federal sources while 90 percent reported that their grants came from non-Federal sources. (These figures are subject to the same uncertainty.)

The study also revealed, however, that only a relatively small group of the science students, 4 percent, received support from foundations. The corresponding figure was only 9 percent for the nonscience disciplines. The proportionately small size of foundation support in this area suggests that the adverse effects of programs for Federal fellowships on Foundation programs of a similar sort are limited.

The National Center for Educational Statistics in the Office of Education is currently working on a study of 20,000 graduate students and within 6 months or a year we should have considerably more (and more accurate) information on these matters.

Response by Dr. Harvey Brooks, Dean, Division of Engineering and Applied Physics, Harvard University, to Questions of the Subcommittee on Science, Research, and Development

1. As a member of the National Science Board, do you believe that a change in the wording of the NSF Act to permit increased operational or applied research by the Foundation would be advantageous?

1. On balance I believe it would be desirable to broaden the NSF Act to permit applied research, although I would recommend that this authority be used sparingly and with discrimination, chiefly in conjunction with its contribution to graduate education in applied science. I do not believe that NSF should attempt to support work in applied science which is clearly and exclusively related to the mission of some other Federal agency. For example, it would be quite undesirable and inefficient for NSF to support research aimed specifically at the improvement of the postal service because there would be little chance of such research results being incorporated into the work of the Post Office. On the other hand, it might be appropriate for NSF to support fundamental work on systems analysis in which an analysis or model of the postal system was used, as it were, as a "test bed" for new concepts and principles of systems design involving social and economic factors as well as technological factors. I do not favor the Foundation being authorized to conduct in-house operations.

2. What are your views as to the appropriate balance in the conduct of basic research as between universities, the Federal Government, and industry?

2. Industry should be encouraged to support basic research which it considers to contribute to its own objectives. In the case of industry doing business with the Government, I support the idea of an industry being permitted to support basic research as a part of its indirect cost allowance on Federal procurement. I am generally opposed to specific support of industrial basic research by small project grants or contracts, except in unusual cases where industry has a unique capability not available elsewhere. Similarly I believe Federal laboratories, whether in-house or contract research centers, should be encouraged to participate in basic research as part of their overall mission. I do not believe it is meaningful to talk about the relative amounts of basic research among different performers. This will vary from field to field depending on its relevance to particular industries or Federal laboratory missions. I believe the present situation in which universities (apart from contract centers) perform about 40 percent of basic research is a fairly healthy one, but because of the special stress which is now being placed on higher education nationally I believe that the proportion of basic research performed by universities should be permitted to grow relative to industrial and Government research, at least until the present graduate student "bulge" flattens out.

3. In view of your comments on the need to avoid insullation of basic science from applied goals, what do you believe is the distribution and attitude among scientists concerning support from the Foundation as compared to other agencies? What mechanisms would you suggest as enhancing the transfer of information from basic to applied areas?

3. My comments on the need to avoid insulation between basic research and applied goals pertained specifically to basic research performed in nonacademic institutions with applied goals; e.g., health or defense technology. However, the same comments apply to some extent to research supported in academic institutions by mission-oriented agencies.

Most university scientists prefer their support to come with as few strings attached as possible. On the other hand, as long as they are free to pursue their research, most scientists like to feel that their work is used by others. Scientists are conscious of the fact that they enjoy the greatest freedom in choice of field of work if they deal with NSF. On the other hand, they also recognize that they can obtain support on a larger scale if their work falls within the field of interest of a mission-oriented agency. A scientist interested in biochemistry, for example, usually has as much freedom and better support from NIH than from NSF. On the other hand, if the progress of his research began to lead him into, say, the physical chemistry of inorganic materials, he would probably ask for additional support from NSF.

The most important mechanism of translation for supported academic research is the corps of scientific program officers in Washington. This overworked and underappreciated group has the responsibility of providing an "impedance match" between the basic research they support and the needs of their agency looking well into the future. This requires being aware of much more than the current problems and "requirements." It demands the imagination and perceptiveness necessary to see where new science could be exploited to fulfill agency missions. This involves not only a thorough understanding of science, but also the ability to reinterpret and redefine both the problems and missions of the agency in the light of scientific possibilities, leading to the creation of what may amount to new missions for the agency. An important function of program officers is to foresee problems of the agency down the road for which basic knowledge may be important; e.g., that basic understanding of radiation damage to solids will be needed because of future requirements for the use of electronic equipment in space. I believe that one of the reasons support of basic science by the mission-oriented agencies has faltered in recent years is that there has been insufficient appreciation, both within the Government and within the academic community of the vital and creative role of the scientific program officer. As programs grow the number of such officers must grow also, so that they have the time and the freedom from harassment by short-range problems to think creatively about their job.

Within institutional laboratories the important concern should be that where the laboratory has an applied mission even the basic scientists understand and believe in the mission and are prepared to devote some of their effort to thinking about the applied part of the program and pointing out where basic science could contribute to it.

4. Your testimony on July 14 emphasized academic research, as distinguished from the education of students or the training of teachers. This raises a question as to which role is more important for Foundation support—the promotion of scientific research or the advancement of science education? As an educator, what is your answer?

4. The essential point is that academic research and the training of students, especially graduate students, are not separate or conflicting functions. For example, the NSF fellowship and traineeship programs would be virtually worthless if there were no research support available for the students to work on their Ph. D. dissertations. Even at the lower level of undergraduate or high school teacher instruction, what is taught depends on advancing research. Science, even at the undergraduate level, is not a fixed body of knowledge which can be poured into the student once and for all. Thus my answer to the question is that both are important and over the long run should be kept in some kind of balance. From year to year, however, some problems may require greater attention than others. At the present time I believe the two most urgent problems are the development of and realization of research capabilities in universities through science development and the basic research grant program, and the intensification of work on the improvement of science curriculums at the college level.

5. You stated that "It is a commonplace that the universities are the appropriate and logical locations for much of the Nation's basic research." Do you see any danger in this policy of turning our colleges into great research laboratories, possibly at the expense of teaching?

5. The danger, of course, exists. During World War II some colleges were turned into great research laboratories in support of the war effort. The best people were recruited from smaller institutions all over the country and concentrated in a few large universities and research centers where they had no contact with teaching. For the most part teaching was done by mass production and was training rather than education. The output of Ph. D.'s dropped precipitously. All of these developments were justified by the war emergency. They did no permanent injury to science because the balance between teaching and research was rapidly restored when the emergency ended. Nothing resembling this wartime trend is discernible in the present situation, nor do I see any likelihood of it, short of a tremendous injection of funds for some kind of crash program. In most cases the aims of basic research and education are congruent, not in opposition.

Some problems are beginning to appear owing to the changing technology of certain research fields, most notably high-energy physics. Here it is often difficult to adjust the needs of education to the requirements for the advancement of science. Facilities for research at the frontier are so complex and expensive that they must be concentrated at a few centers, and this requires that faculty and graduate students be away from the campus for much of their time if they are to participate in such research. But people are aware of this problem and are making ingenious organizational inventions to overcome it.

Throughout history the greatest researchers have had an irresistible urge to impart their knowledge to the next generation of scholars.

This urge is so strong that many of the most creative people have preferred to stay in universities despite the fact that the conditions for research are sometimes less attractive than in the best industrial and Government laboratories.

Universities are centers of learning. This implies the responsibility both to develop new knowledge and to pass it on to the next generation. In a great university these functions must be inseparable. Research itself is simply an extension of the learning process to a more advanced level, in which the human teacher is replaced by nature herself. Recent work in curriculum development has, in fact, tended to make the teaching process, even at the elementary level, more like the research process by guiding the student to learn from nature by himself.

6. *Would you object to the National Science Foundation expanding its activities by supporting research abroad either by foreign scientists or support of U.S. scientists on foreign assignment? How about retraining U.S. scientists who had been working abroad and were out-of-date in their speciality?*

6. I am not particularly enthusiastic about the NSF supporting foreign scientists or expatriate American scientists on an expanding scale when there are many good scientists in U.S. universities who cannot obtain support for lack of funds. The NSF may appropriately support foreign scientists when their work clearly enhances the value of domestic programs.

This will occur most frequently in the field sciences where simultaneous observations in different parts of the world are essential or where a special location is needed to obtain certain data. In such cases it may be more efficient to support foreign observers than build or send American scientists and equipment to the location. I believe the NSF should support foreign scientists and international programs mainly when such support enhances our own scientific output.

As regards retraining repatriated American scientists I see no reason for a special program, except possibly in cases where scientists have made large professional sacrifices to serve the Nation abroad as by participating in foreign aid assignments, teaching in underdeveloped nations, or taking up urgent Government posts abroad. Otherwise, I think repatriated American scientists ought to compete on the basis of quality with domestic scientists who may require retraining, but should not be given any additional consideration. They should be eligible along with others for such programs as postdoctoral fellowships, traineeships, or science faculty fellowships just like any other American scientist in the appropriate category.

7. *The best graduate students frequently are unavailable for teaching because the terms of their research fellowship specifically prohibit it. Do you believe research grants to a full degree should permit or encourage some teaching, both as a means of providing flexibility to the graduate and helping in the training of undergraduates?*

7. In most fellowship programs the terms have been modified to permit a limited amount of extra teaching compensated by the university over and above the fellowship stipend. In my experience this has had a dramatic effect on the quality of graduate teaching assistants. I feel the practice should be made universal for federally supported fellowships. Not all my colleagues agree, but my own opinion is that

teaching by research assistants should be permissible up to some percentage of their time, but should be compensated separately so as to give the student a greater sense of responsibility. It is my observation that a limited amount of teaching by graduate students, say not more than one-quarter time, does not interfere with their research progress. There are few people that can spend all their waking hours on research with profit, and most students will take on a limited amount of teaching as additional work without seriously cutting into their research.

8. At what grade level in our modern educational structure does a student chart his course toward science, engineering, social studies, or the arts?

(a) Should the National Science Foundation exert influence by the investment of support at this level?

(b) Do you believe that fellowship or institutional support of pregraduate education should be proportionately increased or decreased?

8. We really know very little about this subject. There is some limited evidence to indicate that students in science and engineering chart their course much earlier than students in other fields; this is especially true for the physical sciences. There is considerable attrition along the way, especially in engineering. The best scientists usually turn out to have chosen science as a career as early as junior high school.

(*a*) This would probably be desirable if we knew how. Apparently the high school curriculum development programs, while greatly improving the preparation of college students in science, has not greatly affected the fraction of students choosing science as a career. Physics has actually fallen off relatively, as has engineering. On the other hand, it may well be that improved high school curriculums will lead to less dropout from science along the way.

Present thinking is that the formative influences may be exerted even earlier, and it is for this reason that many of the leaders in curriculum development are beginning to turn their attention to elementary science and mathematics as well as other nonscience disciplines. I think the NSF should support curriculum development in elementary science to the extent that outstanding scientists and teachers can be interested in participating. However, I believe the limiting factor here is the quality of the people who can be involved in the effort, and broadcast support will have little influence and may even have negative effects. The purpose of such effort is not only to make sure that all children who have a potential aptitude for science have the opportunity to choose science for further study, but also to insure that an increasing fraction of the population will become literate in regard to the spirit and method of scientific inquiry.

(*b*) I do not believe fellowship support for undergraduate education in science as such is especially desirable. Undergraduates are too uncertain of their abilities and interests and should not be coerced into science by financial considerations. I am not, however, opposed to undergraduate fellowship support provided it is not restricted as to field of study. I believe that institutional support should be increased proportionately, but primarily on a selective basis; e.g., by equipment grants for undergraduate laboratories, or to support innovations in undergraduate teaching, or to support faculty development in non-

research-oriented institutions. For the most part such support should be given competitively on the basis of quality.

9. Since the creation of NSF in 1950, there have been created within the executive branch, the Office of the Special Assistant to the President for Science and Technology, the President's Science Advisory Committee, the Federal Council for Science and Technology (of which the Director of NSF is a member), and the Office of Science and Technology (in which is now vested the previous national policymaking authority of the Foundation). Question: What science policy function does the National Science Board now serve which is not adequately provided for by existing organizational arrangements within the Executive Office of the President?

9. Policy is not a finite or homogeneous entity which can be cleanly separated from operations. Policy is made at every higher level of Government. Every policy decision has to be interpreted in terms of its concrete application to the problems and issues which arise at each level from the President down and such application itself constitutes policy. The National Science Board has to interpret Office of Science and Technology recommendations in terms of their implications for the Foundation's programs. In the budgetary competition the science Board usually takes responsibility for decisions as between programs inside the Foundation, but the Science Board cannot properly advise on its own programs which may compete budgetwise with programs in other agencies. To an increasing degree the Science Board has been taking the initiative in making policy recommendations with respect to programs or administrative matters which have Government-wide implications, but obviously such recommendations have to be correlated with those of other agencies. In my experience the creation of OST has greatly enhanced the role of the Science Board, because the OST supplied the mechanism by which Board recommendations can be translated into Government-wide policy. Without OST the Science Board had nobody to talk to in the Executive Office, since there was no mechanism for harmonizing and correlating its recommendations with the rest of the Government's science activities.

It is even literally inaccurate to state that the previous policymaking authority of the NSF is now vested in OST. This authority is by explicit statement of Reorganization Act No. 2 shared between NSF and OST, with the Foundation still retaining primary responsibility for policy in basic science.

10. Since you have served simultaneously on the National Science Board, the President's Science Advisory Committee, the Committee on Science and Public Policy of the National Academy of Sciences, and as consultant to the Office of Science and Technology, have you seen examples of confusion because of overlap in policymaking roles between these bodies?

10. I have seen no evidence of confusion to date in the various policymaking roles. I admit that such confusion might arise if there were not close liaison between the various groups. So far, for example, the President of the National Academy has been a member of PSAC and the Chairman of COSPUP, a consultant-at-large to PSAC. One or two members of COSPUP have also been PSAC members, and members of OST staff and of the science planning activity of NSF have participated frequently in COSPUP deliberations. For example, an

OST staff member attended many meetings of the COSPUP survey panels for physics and chemistry and ground-based astronomy as an observer. Confusion is avoided because COSPUP is not a Government organization, and it is understood by all that its views and reports do not represent official policy of the U.S. Government. Its function is to present representative views from the scientific community for the consideration of the Government. In no sense does it make policy. Its studies have been confined primarily to the area of "policy for science" whereas PSAC has devoted most of its attention to the area of "science in policy." OST and PSAC reports are part of the Government policy process; they are true "policy staff papers"; i.e., they propose actual policy positions for the Government. In general the role of PSAC has been primarily one of throwing new ideas and new considerations into the policy arena, while OST has concerned itself more with the ongoing process of hammering out policy, including but not confined to the innovations and critiques provided by PSAC and its panels.

11. When the NSF was created in 1950 with a budget limited to $15 million, the National Science Board could, presumably, exercise close supervision over the workings of the Foundation. Since that time, the budget of the Foundation has increased to about $480 million and the Board has delegated much of its authority to the Director, keeping for itself the authority for major policy decisions. In effect, then, the Board serves as a sort of board of governors, and is the only such nonregulatory agency with this form of dual (Board and Director) authority and responsibility. The question then arises, Is it in the best interest of the country and of science in general to still maintain this dual authority, or would it perhaps be better to have the Director solely responsible for the management and operation of the Foundation, and have the Board serve in an advisory capacity to the Director (a National Science Advisory Board)?

11. On balance my view is that the Science Board should be advisory to the Director. This was my position in 1961 when I was developing a PSAC position for Reorganization Plan No. 2, and my subsequent experience as a Board member has reinforced my conviction. My only reservation about making the change now is that it might be misinterpreted by the scientific community. The one concrete advantage I can see in the present arrangement is that it protects the Director when and if he is subjected to improper political pressures regarding the distribution of funds or other decisions. He can then state that he is legally constrained by the approval or disapproval of his Board. But organizationally I think the Director should have sole responsibility for the management and operation of the Foundation. One argument often used in favor of the present arrangement is that the Board would insulate the university community from an arbitrary or incompetent director. On the contrary I think that if the Board were advisory it would be in a position to speak out much more freely if it became dissatisfied with the management of the Foundation. If the Board were made advisory, however, I believe the membership should still be subject to Presidential appointment and Senate confirmation, and that it should be chosen in approximately the present manner, with nominations from professional societies and other representative groups.

12. Dr. Don Price stated that the real input of the scientific community to the programs of the NSF came from the various Advisory Panels and not from the National Science Board or the Divisional Committees which were recently abolished. Would you care to comment?

12. If I understand correctly what he meant, I agree with Dr. Price's statement. I take it he intended to indicate the scientific views of the scientific community, e.g., their views as to what fields were ripe for support, who were the leading investigators, what criteria should be used in selecting projects, what the priorities were among projects, etc. On the other hand, the Board does concern itself with broader issues such as the creation of new national centers, the overall allocation of the budget, policies regarding payment of faculty salaries, the development of new programs, etc. Both inputs are essential.

13. Supplementing your testimony, do you feel that the Foundation has allocated sufficient resources to study national policy, considering that the amount spent each year is considerably less than that being spent; for example, on Project Mohole?

13. I am not convinced that substantially more money allocated to the study of national policy would produce a significantly better product than we are now getting. The amount of money allocated to any given topic is not necessarily proportional only to its importance. It also depends on how much is required to obtain a given quality of output. The only choices with respect to Mohole are to do it or not to do it. One might decide that it is not worth the price, but one could not decide to buy half a Mohole. Similarly, I don't think twice as much money would buy twice as useful science policy. It might only buy confusion. I think science policy is important, and we should be prepared to devote greater resources to its study when and if promising opportunities become apparent—including people with the competence to do the work.

14. Would not your "proposal pressure" system for priority lead to encouragement of fads and fashions? Also, how should the Foundation deal with "proposal pressure" in concrete terms in view of the hazards of inflation of proposals? In fact, what is the significance in the present sharp variation as between different fields of science in percent of funds awarded as compared to proposals received?

14. I perhaps overstated the case for "proposal pressure" because I felt it had been critcized excessively. It is not clear to me how proposal pressure would lead to fads. Fads in science are usually stimulated by the publication of fundamental new discoveries which open new possibilities for scientific advance over a broad front. They are not all bad. Indeed they are sort of the free enterprise American way of achieving concentration of effort in important fields without fiat from above. The philosophy of proposal pressure is based on the concept that the collective judgment of many working scientists as to what is important and significant is likely to be better than the judgment of any single committee or program administrator. Fads are always a hazard in any human community, but by and large I believe collective fads among intelligent, dedicated, and informed people are less likely to be harmful to science than administrative fads, and that's why I put my faith in the collective wisdom of the scientific

community. As I indicated in my testimony the task of the competent program administrator is to discern this collective wisdom with the proper discounts for personalities or other factors which a good man in contact with his field and his advisory groups usually can make. Inflated proposals are very hard to get by advisory committees, especially if there is not enough money to support all proposals. Proposal pressure is a measure of priorities only if the number of proposals exceeds the number that can be supported. It is a measure of relative priority not of the total amount of money that should be allocated to a field. Regarding the last question, there is a wide variation among program officers in the degree to which they discourage proposals orally when they know there are insufficient funds. I believe this accounts for most of the variation between different fields. In small communities such as astronomy the program officer usually knows the field well enough to be able to discourage verbally applications which are not likely to be supportable. Thus there is a high percentage of support of proposals actually submitted formally. I would never suggest that proposal pressure should be used as a rigid formula for determination of priorities. However, I do say it is a useful and significant input to the decision process when tempered by good judgment and sound knowledge of the actual content of the science.

15. Have problems in collection and analysis of statistics by the Foundation come to your attention as a member of the National Science Board; as for example, through the criticism in the recent reports of the National Academy of Sciences? More specifically:

(a) Do you think the Foundation is using adequate up-to-date instrumentation for its statistical procedures and for data collection?

(b) Can you suggest other ways in which NSF's compilation and analysis of statistics could be improved as to completeness, timeliness, and authenticity?

(c) Has the Board acted on this general problem?

15. I would not have interpreted the statements regarding statistics in the NAS reports as criticisms of the Foundation. The remarks in my own paper were directed not so much at the statistics themselves as at overly simplified interpretations of them that have often been made. Statistics never satisfy everybody because everybody wants them for a different purpose. There is still no general agreement either within the Board or within OST as to what statistics are most relevant and useful for policymaking. The collector of statistics always finds himself in the position of trying to outguess the policymaker, to decide what statistics he will want 2 years from now. This is not easy, and one cannot blame the NSF for occasionally guessing wrong when the policymaker himself (including myself) isn't quite sure what he wants.

(*a*) On the whole, yes. This is in the course of modernization. The biggest problems lie in the sources of the original data rather than in the massaging of the data at NSF. Most of it must be collected by questionnaire, and there is already a surfeit of government and other questionnaires. Furthermore, the hidden costs of collecting data by questionnaire are probably very high, and

one has to make a careful evaluation of the usefulness of each piece of data in relation to its cost.

(*b*) This is under discussion in OST and the National Science Board. Improving statistics is a matter of constant feedback between user and producer. I would hesitate to make any suggestions publicly without careful checking with the professional collectors of statistics. My ideas might be totally impractical and would only prove an embarrassment later. In particular, the costs involved in new statistical programs may be too high. On the whole I feel I have little to add to the few suggestions I made in my written testimony.

(*c*) Only to the extent of encouraging the Director to upgrade the planning activity in NSF, and in constituting a long-range planning committee of the Board which concerns itself with the information needed for planning as well as planning itself.

16. What long-term role do you see for the smaller colleges and universities in science and education? Has on-campus research become so important that those institutions which cannot afford it must sooner or later withdraw from education in the life and physical sciences?

16. This is an exceedingly difficult problem which, in my opinion, has not been fully faced up to by the scientific community. By and large the NSF staff has led the way here rather than waiting for initiative from the scientists. The principal problem of the smaller campuses is how to attract competent physical scientists without providing them with on-campus research opportunities. I do believe the weaker of these institutions will be gradually forced to withdraw from serious education in the sciences. However, I believe there are many measures that could be taken which will at least slow this process and preserve the position of the stronger institutions among this group. Some examples are:

(*a*) Curriculum development at the college level and wide dissemination of teaching materials which can be used in colleges. The NSF is already supporting work in this area and could support more if funds were available.

(*b*) Specific support for college faculty members to return to university campuses or national centers for research experience, also for travel to professional meetings, etc.

(*c*) More collaboration between universities and colleges on a regional basis, with Federal support to take care of the incremental costs.

The NSF has already initiated a number of programs along these lines.

17. Is sufficient support being given to the social sciences by NSF and other Federal agencies?

17. Federal support for the social sciences has been growing more rapidly than for any other scientific area, but the growth is taking place on a very small initial base. On the other hand, Federal support for the social sciences in universities actually exceeds that for chemistry, for example. The difficulty is that this support is quite selective, with principal emphasis on fields relevant to mental health. At present we lack clear evidence that there are good ideas for research in the social sciences which are not being explored for lack of support. I think there is a need for a more systematic and expansive study of

possible opportunities for research in the social sciences than has yet been made. This may be an example of where "proposal pressure" is not a sufficient index of what could be done if funds were available and a few leading scientists were encouraged to think in terms of much more ambitious projects. A new study of the social sciences is being planned by COSPUP.

18. Have the cooperative fellowships and graduate traineeship programs succeeded in balancing the tendency for fellows to seek training only at a few top-rated schools? Or has this attempt at dispersal of support to more schools been diluted by other concentrating effects of Federal funding in institutions of higher learning—for example, by the concentration of research grants, research facilities and the location of research centers? Has the number of centers of academic excellence grown?

18. It is hard to define "success" in this area. If an equal distribution of fellows regardless of quality of institution is considered as an objective in itself, then the program has not succeeded. On the other hand, the traineeships particularly have resulted in a wider distribution of awards. By any statistical measure we can devise, the concentration of research funds and of Ph. D. production has decreased in the last 15 years. In fiscal year 1950, 11 universities spent 50 percent of Federal research and development funds, and 65 accounted for 90 percent, whereas by 1962 the first 10 institutions accounted for only 38 percent of the funds, 20 accounted for 50 percent of the funds, and 100 for 90 percent of the funds. In these terms the concentration has decreased by almost a factor of two. In 1930–39, 10 institutions produced 49 percent of the science and engineering Ph. D.'s but by 1960 they were producing only 35 percent. The proportion of Ph. D.'s produced by the first 15 institutions dropped from 65 percent to 46 percent. Although no statistics are available the impression among observers is that spread of quality has been faster in those fields which have been federally funded. There are probably more very good chemistry departments than history departments, for example. If one is to complain about "concentration" I think it cannot be in terms of saying that Federal funds have increased concentration but rather of saying that they have not produced as rapid a dispersal of quality as might have been desirable for other than scientific reasons. The number of centers of academic excellence has certainly grown. The most dramatic increases in Federal funding in percentage terms have occurred in institutions which were of negligible scholarly importance 10 or 15 years ago.

19. It was brought out at the hearings that a considerable transition has occurred in the character and content of college education in science and engineering in the last quarter century. Is it true that today's academic engineering supersedes or perhaps controverts some of the principles that our engineering colleges taught in the 1920's and 1930's? What has been done to attract older professional people back to school in order to update their technical capabilities?

19. The content of engineering has completely changed since the 1920's and 1930's. For example, at that time electrical engineering was largely power engineering and heavy electrical machinery and transmission equipment. Many electrical engineering students never heard of Maxwell's equations. Today whole new areas of physics

and mathematics have appeared as part of the engineering curriculum: the propagation of electromagnetic waves, solid state physics, atomic physics, information theory, the computer sciences, modern automatic control theory, and most recently optics connected with lasers. Similarly in aeronautical engineering the whole science and engineering of supersonic flight and of hypersonic flow is a relatively recent development important in engineering education. All of these represent aspects of engineering that never existed before, and many are based on principles which were not known. On the other hand, it would not be correct to say that today's academic engineering controverts principles taught in the 1920's and 1930's. It is just that the principles of the 1920's and 1930's are not enough for today's engineering.

There has been considerable activity in the area of attracting older professional people back to school. A number of universities and technical schools such as MIT have extensive programs in this area.

Response by Dr. James A. Shannon, Director, National Institutes of Health, to Questions of the Subcommittee on Science, Research, and Development

1. In your testimony on July 14 you identified NIH as "not primarily a science agency," but rather a health agency, utilizing science as a means rather than considering it as an end. Accordingly:

(a) What do you believe to be the relative roles of NIH and the National Science Foundation in the support of the biological sciences?

(b) In the same context, how about the social sciences?

1. In their support for particular disciplines in the biological and social sciences, NIH and NSF follow quite differing principles; however, the principles followed are those characterizing each agency's engagement with science generally. Distinctive missions contribute to these differences. Distinctive missions have generated diverse sources of Federal support—the overriding pattern for science that has evolved since World War II. (In this pattern, the main flow of support for science has been through nonscientific agencies, which have been permitted—and indeed encouraged—to use science as a means to accomplish defense, space, health, and other social goals.)

Because NIH has a health and not a science mission, NIH supports science disciplines only to the extent these are considered to have "health relevance" (i.e., may contribute to understanding or solution of health problems). The judgment on "health relevance" of particular disciplines must in some part be intuitive or a priori. But for any discipline, there is a more objective measure in the aggregate number and significance of projects that have been proposed and individually judged to have health relevance. Where this health relevance is seen clearly (as it is most certainly in the biomedical sciences) NIH will provide support within program guidelines both for current research projects judged to be meritorious, and to enlarge the resource base for continued growth in the future. In accordance with this principle of health relevance, NIH provides support for basic and applied research projects in all fields of science as well as for related fellowships, training grants, and research facilities and resources.

Thus, NIH provides support in depth for the biological sciences but with preponderant emphasis upon disciplines such as biochemistry, pharmacology, biophysics, genetics, microbiology and physiology among others which undergird the study of human organisms, disease phenomena, and health problems. In planning its programs NSF takes into account the primary interests of mission-oriented agencies and serves to provide basic research support in fields and disciplines within the biological sciences which are not emphasized in the mission agency programs such as botany and zoology, assuring that research in these fields does not languish. NSF also provides support for

highly specialized fields such as marine biology in a few major national centers. NSF activity in biology is also concerned with improvement of secondary school teaching through summer institutes for high school teachers, curriculum improvement, and meeting other educational needs at the secondary, undergraduate, and graduate level. NIH activity is confined to support of research and research training at the graduate and postgraduate level.

The NSF–NIH relationship in respect to the social sciences is of a comparable nature.

2. You said NSF "occupies the keystone position in the arch of our Nation's science support and science advancement programs." What guidelines influencing NIH programs are provided by NSF in this key position?

2. The comment that NSF occupies a "keystone" or "central" position among Federal agencies supporting science was not intended to suggest NSF issuance of guideline for mission-oriented programs. Rather, it referred to the unique statutory roles of NSF in support of sicence and science education as ends in themselves. Thus NSF programs in science constitute the essential element in Federal science support activity that together with the several missions creates a cohesive whole. It referred also to the fact that any significant change in NSF support role (for example, assigning NSF exclusive responsibility for basic research support; or, alternatively, for supporting applied research activities on a much greater scale) must have an important impact on the ability of other science support agencies to fulfill respective missions.

Although the functions initially assigned NSF by statute and Executive order strongly stressed science policy responsibilities and implied some degree of responsibility for general guidance of Federal science programs, no guidelines relevant to NIH were issued; and in the Reorganization Plan of 1962, this responsibility for guidance was passed to the new Office of Science and Technology.

As an instance of specific provision of leadership in solution of common science problems, one may cite the semiannual conferences on fellowship programs which are held under the auspices of NSF. At these conferences, managers of the various agency fellowship programs try to work out common approaches to stipends, support levels, and other policy and procedural matters.

3. What is the relationship between NIH and the Office of Science Technology at the White House?

3. The relationship between National Institutes of Health and the Office of Science and Technology at the White House is, in most respects, essentially comparable to that of all other agencies.

In some respects, however, the National Institutes of Health's experience is unique. First, the quality of science sponsored by the National Institutes of Health and the planning and management of its programs was the subject of an intensive inquiry. In February 1965 the results of this inquiry were presented to the President by the Wooldridge Committee in its report, "Biomedical Science and Administration: A Study of the National Institutes of Health."

The Committee, in its acknowledgements, stated that:

> Few committee reports have had a stronger reason for extensive acknowledgments than has this one. In all, nearly 1,000 competent and busy people have been involved to the extent of hours, if not days or weeks, in the study here

reported. The largest number—about two-thirds of the total—must be saluted only anonymously. They were the scientists and administrators in the many universities, medical schools, hospitals, corporations, and research institutes into which the path of investigation led. Despite the disruption of effort, induced inefficiency, and sheer nuisance value of the invasion by visiting experts, the institutions involved displayed a degree of patience, cooperation, and helpfulness that contributed immeasurably to the success of the mission.

Anonymous acknowledgement will not do for the scientists and administrators upon whose information gathering the study was based. These exceedingly busy men took, on the average, several weeks out of their heavy schedules to visit laboratories and clinics, talk to scientists and administrators, and write reports.

* * * Finally, something must be said about the subject of the investigation—the National Institutes of Health. It would have been understandable if the underpaid and overworked scientists and administrators of this organization had opposed the investigatory activities of the Committee and its inevitable interference with the demanding business of NIH. Perhaps some of them did. Nevertheless, the overall quality of the response was high. Despite the very considerable amount of extra effort that they had to put in to answer the inquiries of the Committee, its panels and staff, the NIH representatives, from Dr. Shannon on down, were admirably helpful and cooperative. The general impression this gave was that of an organization with nothing to hide. This was consistent with the conclusions reached by the Committee as a result of its study.

Secondly, the National Institutes of Health as a bureau within the Public Health Service of the Department of Health, Education, and Welfare does not participate directly in the activities of the Federal Council of Science and Technology. It is, of course, represented by the Department's Federal Council of Science and Technology member, the Assistant Secretary for Health and Medical Affairs. The National Institutes of Health's staff, when called upon, participate fully in the subcommittees and panels of the Federal Council of Science and Technology, and other ad hoc groups advisory to the Office of Science and Technology. The Director of the National Institutes of Health serves in a technical capacity, as a consultant at large to the President's Science Advisory Committee and its Chairman, the Director of the Office of Science and Technology. The Director of Laboratories and Clinics of the National Institutes of Health serves as a member of the Standing Committee of the Federal Council of Science and Technology.

4. Do you consider the Policy and Planning Council for NIH proposed in the Wooldridge report similar in responsibility and function to the National Science Board? What changes would establishment of such a council imply for NIH?

4. The answer to this question is "No." Although the Wooldridge Committee did not spell out precisely what duties and responsibilities it considered appropriate for the Policy and Planning Council it recommended for NIH, it is quite clear the Council would differ significantly from the National Science Board. The National Science Board is the policymaking body for the National Science Foundation. In addition to establishing general policies for the Foundation, the Board must either approve, or delegate authority to the Director or Executive Committee to approve fellowships and grants or contracts for basic scientific research activities. By contrast, the only responsibility of the Policy and Planning Council for NIH would be to provide the Director, NIH, with the best possible advice on the total NIH program—particularly long-range planning aspects and optimum allocation of resources to achieve policy objectives and program goals. There is no implication in the Wool-

dridge report that the advice of the Policy and Planning Council would be binding on the Director, NIH, as would be those of the National Science Board on the Director of NSF. The two bodies would be similar, however, in their focus on major policy and program issues, and their freedom from concern for day-to-day operating details of respective agencies. Moreover, a similar mix of national science and public affairs leaders would constitute the membership of both bodies. These bodies, therefore, would tend to provide similar reassurance that in the development of these key national programs, the views of the scientific community and of the public are heard and weighed.

5. The primary mission of NIH, as you put it, is "the support of medical research." Supplementing your testimony:

(a) How do you distinguish between basic and applied research?

(b) What proportion of total research funds do you feel should be devoted to each, in the context of NIH's mission?

(c) Do you have any measure of the rate at which funds for basic research in the universities should increase?

(d) What are NIH's long-range plans in this regard?

5. (*a*) Great material advances in man's health and well-being depend upon the "breakthrough" discoveries which emanate from fundamental research. Pragmatically, basic research is the pursuit of knowledge which does not yet exist; applied research is the application of existing knowledge to solve problems, to innovate or improve processes and products, and in the field of medicine, for example, to advance etiology, diagnosis, therapy, and rehabilitation.

However, as Dr. C. V. Kidd observed:

> Descriptions and definitions of basic research have at least two kinds of potential uses. The first is to convey—generally to nonscientists—a sense of the nature of basic research, a feeling for its importance, and an appreciation of the motives and working conditions of scientists. One ultimate purpose served by such a description is to expand the scientific capacity of the country by creating understanding of, sympathy for, and support for, the full array of conditions that seem to be conducive to the production of basic findings.
>
> To serve this function satisfactorily, basic research can be described in general, impressionistic terms, and logical precision is not required.
>
> A second use of definitions of basic research is to provide rational, and adequately precise, criteria for decisions required in classifying research as basic for the purpose of compiling statistics * * * basic research can be and has been adequately for the first use, but basic research has not yet been defined—and may never be defined—so as to permit an unambiguous, objective measurement of the dollars spent for basic research in this country.
>
> Definitions of basic research in terms of such factors as the degree of freedom with which the investigator works and the prospective applicability of his findings are useful in making administrative decisions on the support of research. In practice, administrators do not decide to support work because it is basic or not basic. Indeed, the term "basic research" is used much less frequently in the day-to-day business of research administration than it is in communicating with the nonscientific world. Administrators consider the man—his past performance as judged by his peers—even though the merit of the research project is ostensibly the basis for judgment. They consider the facilities available to him. They take into account the support available in his field—whether it is a "gap area" or one well financed. What those who make decisions cannot do and do not attempt to do is to judge the intentions and the motives of investigators. Definitions of "basic research" in terms of motive and intent are, in practice, used by administrators—those who participate in decisions on the distribution of research funds—neither in administering research nor in collecting statistics on research.

The NIH is very much in accord with the views of Dr. Kidd in respect to the utility of distinction between basic and applied research in administering science programs. Therefore, in the operation of NIH programs no such distinctions are made.

The NSF in collecting statistics from Federal agencies on their expenditures for basic research defines "basic research" in terms of the motives or intent of the individual investigator. In responding to NSF the best estimates possible are made of the distribution of expenditures in accord with these definitions. Under these circumstances, NIH expenditures reported in the "Federal Funds for Science" series reflect a consistent pattern of approximately one-third basic and two-thirds applied.

(*b*) When NIH support for research is viewed in terms of scientific content rather than the intent of the investigator, we estimate, that two-thirds for fundamental research in support of NIH missions and programs and roughly one-third applied research. We regard this ratio as a reasonable one for the present. Looking ahead, as greater effort is devoted to costlier applied research opportunities; e.g., bioengineering, organ transplants, vaccine development programs, this balance may be modified somewhat but not at the expense of fundamental inquiry essential for the advancement of the Nation's health through research.

(*c*) In specifics, no. In general, support for the conduct of academic science should grow at the rate necessary to sustain the present body of ongoing science in light of increasing substantive and economic cost factors and provide for the support of the new investigator emerging from training programs and general institutional needs related to strenthening the scientific environment and resources of the institution.

(*d*) NIH long-range plans are to expand support for fundamental research in all fields of science directed toward the development and use of scientific knowledge in the following areas:

1. The causes, diagnosis, treatment, control, prevention of, and rehabilitation relating to the physical and mental diseases and other killing and crippling impairments of mankind;
2. The origin, nature, and solution of health, problems not identifiable in terms of disease entities;
3. Broad fields of science where the research is undertaken to obtain an understanding of processes affecting disease and human well-being;
4. Research in nutritional problems impairing, contributing to, or otherwise affecting optimum health;
5. Development of improved methods, techniques, and equipment for research, diagnosis, therapy, and rehabilitation.

Growth should be related to social needs, scientific opportunities, and the availability of human and physical resources. The pace of growth should be responsive to the interplay of these critical variables rather than Procrustean formulas. In these terms present estimates suggest an increase in national expenditures for medical research (both public and private) from $1.9 billion in 1965 to $3 billion in 1970.

6. In your judgment should NSF give greater support to the basic research activities of the nonprofit institutions as well as the universities?

6. Although the broadest base of fundamental activity exists either in universities or university-related institutions, the National Science Foundation has supported from the beginning of its activities, many other private nonprofit research organizations or laboratories, most notably inland field stations and marine biology laboratory facilities, some of these offering entirely unique opportunities for specialized research. Certainly, any expansion of NSF support should encompass such institutions as well as the universities. The balance of the support should be related to the need and it would seem unwise to attempt to tie it to any fixed formula or proportion.

7. Is consideration given by NIH to the geographical distribution of research grants?

7. The National Institutes of Health is a mission-oriented agency. Its statutory objectives are the solution of the major disease problems confronting mankind and advancement of knowledge relating to disease, the nature of the underlying biological processes, and the means and methods for the most effective diagnosis, treatment, and prevention. In this context the role of NIH in the support of science is derivative of the primary objectives set forth above. Consequently, the principal determinants bearing upon selection of research projects for support through grants are (1) the scientific merits of the proposal and (2) the relevance of the proposed research to the overall mission objectives encompassed in the NIH programs. An important objective of NIH activity, however, has been the strengthening of the national system of medical research and research training and the enlargement of the capability of the Nation in the areas of scientific and academic activity important to the advancement of the Nation's health. Thus in a variety of ways NIH programs have contributed to the growth of institutions throughout the country. This has enlarged the number and distribution of scientific centers in the biomedical area and improved the national distribution of research and research training in the biomedical field. This effect of NIH activity is not the result of deliberate decisions based upon geographical considerations but upon judgments arising from the framework of NIH scientific advisers on the institutions and programs of potential throughout the country. The result has been an ever-widening geographical dispersion of biomedical research activity in the United States. It is a consequence of qualitative judgments rather than geographical objectives.

8. It is apparent from the hearings that NIH differs markedly from NSF in its responsibility for in-house laboratories. Could you comment on the role of such laboratories and their future in relation to Federal support of extramural research?

8. Although the intramural and extramural components of the NIH programs are, in many respects, independent activities, the grant-in-aid programs derive considerable benefit from being administered by an organization that has recognized competence and long experience in the conduct of both laboratory and clinical research.

The relationship of NIH intramural scientists to the extramural programs is usually informal. The NIH scientist is no more likely than his university counterpart to be appointed to a study section or other advisory group because a deliberate effort is made to give the membership of the review groups a wide geographic distribution (in

order to draw on all segments of the scientific community and to facilitate site visits). The intramural staff is however, frequently consulted on program problems and asked for information and advice on the varied technical questions that arise during the review of grant applications and in the course of policy and program discussions involving the substance of scientific research. The volume of such informal consultation is largely undocumented but is high enough to elicit occasional complaints from the scientists that too much of their time has to be spent in this way.

As it is no longer necessary for the NIH grant programs to be mainly focused on building up the national research base, more attention is being given to the deployment of effort in the support of specific research and developmental goals for which sophisticated scientific guidance is indispensable. As a result, there is now a need and an opportunity for developing a comprehensive institute approach to each of NIH's categorical missions in which the intramural and extramural programs will become increasingly interdependent. Several institutes—notably the National Cancer Institute—have already taken steps to involve their intramural staff on a more formal and continuing basis in the development of institute policy. This trend will clearly continue.

The growth of collaborative programs is an important feature of this evolution. Such cooperative ventures can play a most effective role in bringing a massive and coordinated research attack to bear on specific disease problems and are essential to major developmental research projects in such complex fields as bioengineering, large-scale biometric and epidemiological studies, the application of automation techniques to laboratory and clinical procedures, and the development of artificial organs and supportive devices. In activities of this kind NIH must depend heavily on the competence of its in-house scientific staff.

The scientific staff is also a useful reservoir for the recruiting of scientist-administrators for NIH and, indeed, for other parts of the Public Health Service.

The intramural activity makes another significant but subtle contribution to the extramural programs which is at least as important as the direct assistance it provides. The role of NIH as an outstanding research institution pervades the Bethesda campus and provides a setting that has imperceptibly, but nonetheless profoundly, influenced the development of the whole organization. The prestige conferred on the whole of NIH by the eminence of some of its scientific staff and the solid base of experience provided by NIH's direct involvement with the leading edge of research has won for it an acceptance—by the scientific community, by the public, and by the Congress—which it could not have achieved—and would not be able to maintain—as merely a Government agency charged with responsibility for the disbursement of Federal grant-in-aid appropriations.

9. The point has been made during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. More specifically:

(a) What guidelines or criteria has NIH established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the agency's jurisdiction and, therefore, should, or should not, be supported by NIH?

(b) If written criteria have been established by NIH, please submit a copy thereof to the committee.

9. As the major Federal granting agency providing support for research on health-related problems, the Public Health Service has published general guidelines describing the types of proposals, including the scientific areas considered relevant, which are deemed pertinent to the mission of the agency. Because of the potential breadth and diversity of fields of science from which significant information may be derived as contributory to a better understanding of health and disease, these guidelines are necessarily broadly drawn. They were described in sections I and II of the widely distributed document, "Public Health Service Research Grant Programs"; these guidelines form sections A, 501, and 502 of the current "Grants for Research Projects, Guide to Operation Procedure." Although now adapted for use relative to all research grant programs administered by elements of the PHS, these provisions originated within the NIH during the period when that organizaion was the sole research granting element within the PHS. With appropriate modifications related the establishment of granting authority within the Bureau of State Services concerning research in the areas of community and environment health, they still describe the general parameters of the NIH research support activity.

It should be further noted that, in the formative years of the NIH and NSF grant programs, discussions of an informal nature were held between operating level officials of NIH and NSF concerning instances of possible program overlap in scientific areas of potential interest to both agencies. The field of chemistry represents an excellent example. It was decided that proposals in medicinal chemistry would be accepted by the NIH whereas those oriented more toward the fundamentals of chemistry per se, such as the nature of a chemical reaction, would be accepted by the NSF. Discussions between potential grant applicants and program officials of either agency have resulted in widespread awareness of this guideline which has stood the test of several years of experience. If the NIH does receive a proposal seemingly more appropriate for funding by the NSF, the application may be returned without further processing with advice that the applicant seek support from the NSF.

The general philosophy which characterizes the NIH attitude in this matter recognizes the difficulty in defining precisely any line of demarcation and the danger to productive program development which might occur if any such line should be drawn too rigidly or arbitrarily. Thus a reasonable degree of program overlap is permitted without distorting the mission of the NIH or creating competition between NIH and NSF.

10. Are you satisfied with the ratio of support between NSF supported research and its efforts in regard to education?

10. NSF bears this responsibility for assessing the adequacy of the current balance between its support for research and for education. NSF has, from the beginning, been sensitive to the need for balance among its programs. In so doing, NSF has contributed significantly to the advancement of science education at all levels as well as to the support of basic research. Looking to the future, it seems reasonable to anticipate that the exanding programs of the Office of Education may enable NSF to increase the existing ratio in favor of basic research.

11. How does NIH coordinate its educational support with NSF, NASA, the Atomic Energy Commission, the Office of Education, and other Federal agencies involved?

11. At the present time, the agencies offering the bulk of Federal support for science or training in higher education institutions depend mainly on informal coordination. This coordination generally takes the form of information exchange—on either common-interest problems or institutions. Informal liaison arrangements also are common. The effectiveness of these coordinating activities varies with the particular programs undertaken and with the various agencies. From these activities, a number of joint funding arrangements result, as well as many referrals of project requests from one agency to another.

An informal interagency group meets semiannually to work out agreements on stipends and fellowship support levels. These meetings have been chaired by the NSF representative; it is anticipated that this task will be shared on a rotating basis in the future, drawing upon representatives from NIH and the Office of Education, respectively. Other informal and formal coordinating arrangements are even more fully developed in the facilities program area. NASA, AEC, NSF, and NIH have been actively engaged in information exchange on requests from various institutions for research renovation or construction of research facilities of one kind or another; and a representative of NSF (as required by Public Health Service Act) sits as a member of the Health Research Facilities Council that reviews requests for NIH support for facilities constructions. With the initiation of the Office of Education's education facilities program toward the middle of fiscal year 1965, the Office of Education called together facilities program representatives from NSF, NIH, and NASA. These met in an ad hoc group for a series of discussions of common problems and distinctive approaches in the facilities program area. Out of these ad hoc meetings (that were held monthly from January through May) came a tentative proposal for a formal interagency working group. This group—if established in proposed form—would advise the Federal Interagency Committee on Education on what progress could be achieved toward common education goals through voluntary interagency cooperation and information exchange. The nature and responsibilities of this proposed interagency group are still under discussion.

12. Are the NIH institutional grants consistent in policy and content with those of NSF, NASA, and other Federal agencies? What lessons has NIH learned from its institutional program that may have relevance to NSF activities?

12. The general research support grant program of the National Institutes of Health while generically an "institutional grant" is restricted for support of health research and research training.

The stimulus for the general research support program had its origin in the postwar growth of the NIH's extramural research support programs and the effects of this growth upon recipient institutions. The research and research training programs of NIH and other Federal agencies had grown to a point where their size and scope exerted a profound influence upon the medical schools and other institutions within which individual investigators work. The GRS program came into being to provide support of research and research training in a way that would not only meet the needs of the individual investigator but would assure the medical schools and other institutions engaged in health research an effective and responsible role in determining the use of a portion of the total Federal funds distributed to them to support biomedical research and research training activities.

In recognition of the importance of meeting institutional needs for control of their own biomedical efforts, policies for the GRS program have been established which encouraged institutions to exercise local initiative and discretion in meeting emerging opportunities in research, in exploring new and worthwhile scientific ideas, and in using research funds in ways that will contribute to long-range institutional development for the improvement of research and the research environment. Included in the goals of the program are (1) stabilization of key research personnel; (2) support of new or exploratory research projects not yet at a stage to compete successfully in national competition for NIH project funds; (3) support of central, institutional resources such as computer centers and animal facilities.

The general research support grant of NIH is generally consistent in policy with those of NSF and other Federal agencies. However, important differences in content do exist in keeping with the restricted mission of the supporting agency. Thus, the primary difference is that NIH restricts the use of its funds to the support of health research and research training activities, but in so doing is able to provide support for a broad range of basic as well as clinically oriented studies. The NSF funds on the other hand are available for the support of scientific fields which are completely unrelated to biomedical research and research training.

Another difference exists in terms of the types of institutions which receive institutional grants; NSF institutional grants are awarded only to universities and colleges, whereas general research support grants provide support to hospitals, research institutes, and research foundations as well as to the individual health professional schools. In 1964 NSF excluded medical and other health professional schools from eligibility for separate institutional grants. It is to be noted that in accordance with the expressed intent of the Congress, the NIH plans to extend general research support to universities and graduate schools this fiscal year.

In administering its program the NSF bases its awards solely upon the research dollar investment which that agency has in an institution, in contrast to the NIH program which has established a formula that recognizes both the Federal and non-Federal support of the health research programs in the institution. The NSF thus has been able to

develop a simplified procedure whereby the institution requests funds and the agency awards them on an almost automatic basis. The differences mentioned, however, have led the NIH to establish a more detailed scientific review and evaluation procedure for its institutional grant program. In its application for GRS funds the institution must (1) list its expenditures for research provided from "outside" sources, (2) provide a statement specifying the manner in which the institution intends to use the grant for furthering its health-related research and research training activities, and (3) provide a statement specifying the practices the institution intends to employ in meeting its responsibility for rendering scientific judgments and discriminations in the allocation and administration of the grant. Whereas review of applications is a staff function at NSF, the GRS program includes staff review of applications followed by a review by a Scientific Review and Advisory Committee composed of eminent administrators and scientists from foundations, research institutions, universities and hospitals, who furnish independent viewpoints on the merits of supporting any particular institution. The objectivity, technical competence, and heterogeneous composition of the Committee, together with the yearly replacement of a portion of its members, help assure that different aspects of health research and health research training receive critical and continuing review. Subsequent to review by the Committee, each application is presented for further review and consideration to the National Advisory Health Council, which in turn makes final recommendations to the Surgeon General.

Unlike the NSF program, under GRS policy each academic grantee receives a base grant of $25,000 plus an additional amount determined by application of the established formula. Schools of medicine, dentistry, osteopathy, and public health have been and presently are considered to be automatically eligible to receive GRS awards. Other types of health professional schools and all other nonacademic health research organizations must meet established criteria before an award can be made.

In reference to the manner in which institutional grant funds may be used for the support of scientific activities at institutions, under the NSF program grantees are allowed to use funds for construction and alterations and renovations, whereas the GRS program proscribes use of funds for these purposes. With this exception, the manner in which funds may be expended under both the NSF and the NIH institutional grants programs are quite similar.

It has been the experience of the NIH through its General Research Support program that appropriate scientific review and evaluation both of applications for institutional support and of the resulting impact which that support has produced in the recipient institution is important to the long-range development and success of the program. Also, it is believed that the establishment of a base grant or a minimum grant for academic grantees has been instrumental in making the program a meaningful mechanism in aiding the institution to improve and extend existing programs and to introduce new kinds of biomedical research and research training activities which are essential to the continued progress of the health sciences.

13. Would you explore the issue of the project grant to an individual investigator, versus the institutional grant? What is the

proper balance between these two systems, now and in the future? Will the new science development programs relieve the need for project grants at these institutions?

13. The project grant in our opinion and in our experience, and in the opinions of every group which has deliberated on this question. has been regarded as a uniquely successful instrument for the support of either biomedical or fundamental (i.e., basic science) research in the partnership between either the Federal Government or some other agency or philanthropic organization and the investigator. There seems little serious question that this method of supporting research gives the best possible assurance that funds will go to the study of the most promising ideas by competent investigators working in adequate facilities. To some degree, it is the success of this means of research support which has been responsible for the emergence of other needs which cannot entirely be met by it. It was in an attempt to meet some of these needs that the general research support grant was developed. They include the following:

1. Support of preliminary exploration of new ideas insufficiently developed to be adequately marshaled in project applications.
2. Support of promising new leads immediately without the delay inherent in project applications.
3. The bridging of inevitable gaps in project support.
4. Temporary support of new staff members who have not yet had the opportunity or the time to obtain project support.
5. The providing of central institutional facilities or resources serving a variety of enterprises and investigators.
6. Support as needed for the necessary internal balancing and strengthening of the organization.
7. Other special local needs related to the overall strengthening of the research effort but in many instances not project oriented.

The general research support grant as a form of broader institutional support was thus developed in support of these and other needs. A relatively brief experience with this mechanism of support has encouraged us to believe that although the project grant should continue to be the backbone of our research support effort that the general research support program should not only be continued but expanded to provide greater flexibility for the expansion of the scientific base of research programs, both by recipient institutions and by us. Specifically, it seems desirable to use the general research support authority not only to the full degree authorized by statute but to extend this authority to support the planned development of biomedical research and training programs of institutions and to enlarge the number of such centers of excellence. It would seem desirable to free at least this portion of such authority from any fixed relationship to existing programs. It will be seen, therefore, that the balance between the two types of support is an evolving one which is still in evolution and should probably so continue as a dynamic force to support the changing needs of the biomedical and scientific community. Within this overall view of the relationship of the two kinds of support, it becomes clear that the new "science development" grants of NSF will, by broadening the base both by number and geographical distribution of centers of excellence in science and engineering for scientific training,

undoubtedly eventually increase the demands by scientifically trained personnel for additional project grants as this additional trained manpower pool becomes distributed both in new and established centers of scientific investigation, rather than in any sense relieving a need for project support.

14. You referred to the statistical data collected by NSF. How up to date, complete, and accurate do you consider this material to be?

14. I believe, as explicitly noted in my statement before the committee on July 14, 1965, that:

The NSF function in measuring and analyzing the quantitative and economic characteristics of science and its resources is basic to formulation of programs and policy.

This function was initially undertaken by NSF in its Program Analysis Office through a series of comprehensive benchmark surveys in 1954 concerning all sectors of the research economy—Government—industry—nonprofit. In the two largest sectors, the Federal Government and industry, these surveys have been repeated annually, and expanded in scope. In other sectors, e.g., nonprofit institutions, the surveys have been repeated at benchmark intervals about every 4 years. Periodically, NSF publishes a transfer table showing the flow of funds from source to performer and providing national totals for each. During this period, NSF has steadily improved its statistical data—more up to date, more complete, more accurate.

The potential utility of this basic statistical series concerning the Nation's R. & D. effort could be greatly enhanced by publication of national totals for the current year, e.g., 1965, in 1965. There is, of course, an element of risk in publishing national totals, when some components must be based upon estimates. Nevertheless, the potential utility, in my view, far outweighs the risk.

The utility of NSF statistical data on the Nation's R. & D. could be significantly improved by inclusion of figures on capital outlays for R. & D. plant and related facilities. The information now provided on the national research and development effort is limited to data reflecting current operating costs; the considerable investment by all sectors in construction of research facilities is lost sight of; the series should be expanded to provide data to measure the effectiveness of programs in maintaining and expending the required physical research resources.

With respect to the considerations of completeness and accuracy, I concur with the excellent statement of Dr. Harvey Brooks, dean, Division of Engineering and Applied Physics, Harvard University, with respect to performance and problems.[1] In addition to the problems mentioned in his statement, I would add only one: How to categorize State universities and other public institutions of higher education? Functionally, they are educational institutions; in our system of national accounts, e.g., GNP, they are encompassed within the public sector. NSF's current practice is to encompass all educational institutions in the nonprofit sector and to treat State appropriations for the support of State universities and colleges as "institution's own funds," when such funds are expended for the support of research. In my

[1] Statement prepared for submission to the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, 10 a.m., July 14, 1965.

view, this practice seriously understates State support for research. This understatement is of little concern at the microlevel, when swallowed up in a national total of $21 billion for R. & D. Nevertheless, at the microlevel, current statistical practice yields a misleading estimate of State funds expended for the support of research—perhaps by an order of magnitude. With public institutions predictably increasing as a proportion of all higher education, this disparity between actual State support and that reported by NSF will continue to grow unless some corrective action is taken.

15. Exactly how do you make use of the Science Information Exchange?

15. The National Institutes of Health has over the years prior to and since the formation of the present Science Information Exchange maintained a deep interest in fostering, promoting, and supporting the aims and functions which the Exchange performs. This interest has been maintained because of the recognition of the need for a interagency source of information on ongoing research programs that have a variety of sources of Federal support. Such a source has acted as a valuable management tool in planning and maintaining research support operations.

HISTORICAL INTEREST IN SIE

The National Institutes of Health provided the historical origins of the present Exchange in an early (1946–50) Information Exchange Section in the Division of Research Grants. As voluntary contributions of information on medical sciences programs from other agencies grew, the interagency scope was recognized and formalized by Federal agency agreements into the Medical Sciences Information Exchange and organizationally transferred from NIH to the National Academy of Sciences, National Research Council in 1950 to enable it to serve the wider information needs of the Federal Government. The NIH has continued during the subsequent years to help the Exchange in its purposes by providing funds through grants and memorandum agreement transfers and has furnished leadership in its governig bodies during its various organizational transformations and name changes to its present state under the National Science Foundation and Smithsonian Institution auspices.

SCIENCE INFORMATION SERVICES TO NIH

The NIH has cooperated fully in supplying SIE with information on its extramural and intramural research operations and has found a profitable return for the investment. The SIE provides certain selected services for the NIH by acting as a central repository for information on currently supported research projects and for those which have been terminated over the past 10 to 15 years.

RESEARCH PROJECT SUMMARY SHEETS (NOTICES OF RESEARCH PROJECTS)

Preliminarily to the meetings of the initial review groups (study sections of the NIH) SIE compiles and makes available booklets of one-sheet summaries (NRP's) for all proposals to be reviewed by each study section. The booklets include summaries of proposals for NIH

support and summaries for projects already supported in the applicant's name by other agencies and private foundations when known. Study section members use these to avoid multiple support of the same research project and to aid in their knowledge of parallel work going on in the laboratory of the investigator.

The NRP serves as a document for analysis, storage, retrieval and distribution of research information to many other offices of the NIH. As a recurring service, SIE circulates to offices such as Research Documentation Section, Research Grants Review Branch and Career Development Review Branch of the Division of Research Grants copies of all NRP's from submitted research projects that are approved and paid. SIE also maintains and will provide on request a list of NRP's on intramural research projects conducted within the laboratories of NIH.

REQUESTS FOR SCIENTIFIC AND ADMINISTRATIVE INFORMATION

Information on the scientific research supported by sources outside the NIH is readily available through the Exchange and has been sought on a number of occasions. There are a number of examples of research topics, e.g., radiobiology, reproductive physiology, marine biology, veterinary medicine, pesticides for which the NIH has had need to make intergovernmental evaluation of support (dollar amounts and numbers of projects) as a data source for manpower and resources analysis. A listing of such types of requests made by NIH personnel and furnished by the SIE over a 5-month period in 1964 is attached to illustrate the search request services provided by the Exchange. The Science Information Exchange system of coordinate classification is unique to any other existing in the Government and permits retrieval of broad scientific topics that have been needed by NIH and were not accessible from other information services.

As an additional service SIE may be asked to retrieve information and documents for terminated projects across NIH Institutes lines and intergovernmentally in many different contexts.

SUMMARY

The NIH has found the Science Information Exchange to be a continuing source of needed information on the support of specific research areas, on the support of specific scientific investigators and by providing data on broad research program areas that are supported by NIH, other elements of the Public Health Service, by other Federal agencies and by private foundations. It is hoped that the recent developments of a combined reporting system agreement between the Department of Defense and the National Aeronautics and Space Administration will provide input to SIE from their programs to make SIE coverage virtually complete for all significant performers in biomedical research.

Through its beneficial experience with the SIE, the NIH strongly supports its continued development as a central national source for substantive information on ongoing scientific research programs supported by Federal programs and private agencies.

REQUESTS MADE BY NIH [1]

(From January to May 1964)

Division of Biologics Standards:
138 Current studies on Mitomycin C, and bacteria and mammalian in vitro.
Mrs. A. K. Reich, Scientific Communications.
170 Photodynamic action in biology.
Mrs. A. K. Reich.
597 SV 40 viral nucleic acids.
Dr. Bernice Eddy.
Division of Radiological Health:
584 Lasers and masers in biology and medicine.
Dr. Paul Hahn.
Division of Research Grants:
76 Data processing related to manpower or training.
Mr. Werner Matteradorff, Statistics and Analysis Branch.
867 Studies on populations which have low incidence of disease.
National Institute of Allergies and Infectious Diseases:
249 The number of virological research laboratories conducting active research.
Mr. George S. Yee, Research Reference Reagents Branch.
National Institute of Child Health and Development:
519 Nonsurgical treatment of hydrocephalus.
Dr. Donald Robinson.
751 All support of meetings in the life sciences area.
Miss Ruth Crozier.
851 Human communication.
Miss Ruth Crozier.
1042 All grants to departments or schools of optometry.
Mrs. Lillian Freedman.
National Institute of Dental Research:
428 Listing of Veterans' Administration projects, by given accession numbers.
Dr. Edward J. Driscoll, Clinical Director.
National Institute of Mental Health:
87 All studies on suicide.
Dr. James Fox, Special Assistant to the Deputy Director.
317 Psychological and social factors related to smoking.
Mrs. Lillie Theobald.
460 Studies on psychiatric nursing.
Dr. Morris C. Leiking, National Clearinghouse for Mental Health Information.
541 Alcohol preference in white rats.
Dr. J. F. Pilgrim, Research Grants and Fellowships Branch.
556 Alcoholism and drug addiction.
Dr. Nathan Rosenberg, Research Utilization Branch.
585 Social maladjustment of adolescents.
Dr. George V. Coelho.
National Institute of Neurological Diseases and Blindness:
61 Epidemiology of optic disorders. Studies on or involving human twins.
Dr. John T. Schwartz, Epidemiology Branch.
304 Acceleration or deceleration injuries to the cervical spine.
Mr. Julian Morris.
753 Neurological bases of reading disorders.
Miss Sylvia Kesinger.
470 Fitting contact lenses to animals.
Mrs. Frances Dearman, Neurology Information.
426 Studies in which monkeys are used in investigations related to cerebral palsy.
Dr. Gilda Marques, Perinatal Research Branch.
769 Molecular biology studies supported by NINDB.
Miss Lois F. Hallman.
816 Cytogenetic studies of prisoners; cybernetics of human development.
Mr. Bob Schrieber.

[1] Listing incomplete. Prepared May 11, 1964.

National Heart Institute:
11 Cause and cure of cancer and congenital anomalies.
Dr. Sheila Mitchell.
451 Lipid research.
Dr. William H. Goldwater, Special Research Projects Branch.
985 Research and development of artificial implatable hearts and kidneys.
Mr. Philip Janus.
National Library of Medicine:
314 Manipulation of spine from an osteopathic or orthopedic point of view.
Miss Virginia MacDonald.
Office of International Research:
569 Stevioside or steviol.
Mr. Harry L. Hornback.
Office of Publications and Reports:
834 Studies on ethno-botany.
Mrs. Lillie Theobald.

16. Do you see important analogies between medicine and engineering that might guide NSF research and education in engineering?

16. National Science Foundation policies and programs providing support for research and education in engineering have evolved during the past 15 years, with guidance from the National Science Board. During this period, National Science Foundation has been sensitive to the advice of the scientific community, the science adviser to the President, the National Academy of Science, the newly established National Academy of Engineering, and the 11 professional societies representing some 900,000 engineers.

As indicated in the National Science Foundation's publication, "Scientific and Technical Manpower Resources" (p. 86), 46 percent of the engineers hold no academic degree, 47 percent received a bachelor's degree, 6 percent a master's degree, and 1 percent hold the Ph. D. In contrast, virtually all M.D.'s receive a minimum of 4 years' training in medical school beyond the baccalaureate level. The training process continues through internships and residency—an additional 4 years of formal preparation on the average. Because medicine and engineering vary so widely in the nature of their training, their functions, their career patterns, and the social and institutional settings in which they work, it is difficult to see how analogies might guide the National Science Foundation.

However, as a member of the Gilliland Panel and a consultant to the Science Advisory Committee, I have heard many lucid presentations discussing engineering research and education needs. The Director, National Science Foundation, in concert with the National Science Board, the Office of Science and Technology, and the scientific and engineering communities, bears the responsibility for judging how the National Science Foundation can contribute most effectively to meeting these needs.

17. From the standpoint of objectives, program content, and management, which of NSF's programs do you consider to be the best, and which do you consider to be the least effective? Also:

(a) What are NSF's notable weaknesses or deficiencies, and how may they be corrected?

(b) What more could the Foundation do to promote the progress of science?

17. The National Institutes of Health does not have the necessary information—nor would we presumed—to identify which NSF programs merit "best" or "worst" descriptors in terms of program content or management. However, in terms of program objectives, value

judgments are possible and probably even appropriate. From the point of view of NIH, we see one imperative function for NSF: that it, providing for the stability, vigor, and balanced growth of academic science. NSF—alone among Federal agencies supporting science—has the broad statutory role in science and science education that makes feasible the successful carrying out of that function. Those programs that contribute to this end—and the great majority of NSF programs certainly do—are the ones that NIH would like to see strengthened and expanded from year to year with the overall objective of assuring continued world leadership for American science capabilities. However, we have noted with some concern the tendency of NSF to pick up responsibility for direction and management of certain large-scale projects such as Mohole, radio astronomy, and weather modification. Mainly, NSF took on responsibility for these projects because they did not fit neatly within the scope of concern for any of the mission-oriented agencies, at the time the research need was perceived.

It is recognized that these large national enterprises are essential on the national science scene. They are particularly valuable when they afford a setting for postdoctoral or interdisciplinary training not available and not feasible to provide at individual universities. But we would not want to see these programs grow at the cost of limiting NSF's ability to expand in its pivotal role in support of academic sciences. Because of the complexity of these major science projects, they must be expected to exact a fairly high proportion of top management and scientific attention at NSF, irrespective of the original program intent. In our view, it would make sense to consider alternative management arrangements for these major projects. If national science objectives in the next 10 to 50 years are to be attained, NSF must be free to direct maximum energy and resources upon the strengthening of academic science, taking into account the strong complementary endeavors of other agencies such as National Institutes of Health and the Office of Education.

18. Has NIH been participating in policy and program planning in education under the new Federal Education Council?

18. The new Federal Interagency Committee on Education, established by Executive Order 1185, is chaired by the Commissioner of Education and includes a representative from each of the following agencies: The Department of State, the Department of Defense, the Department of Agriculture, the Department of Labor, the National Science Foundation, the Atomic Energy Commission, and the National Aeronautics and Space Administration.

As indicated in the response to question 11, along with representatives of NSF, NASA, and the Office of Education, NIH has been intimately involved in development of a tentative proposal for a formal interagency working group which, if established in its proposed form, would advise the Federal Interagency Committee on Education on what progress could be achieved toward common education goals through voluntary interagency cooperation and information exchange.

Because of our substantial support for health research, training, and the development of resources for the future in the Nation's scientific and educational communities, it is anticipated that NIH will be called upon to provide staff assistance and to participate, as requested, in the activities of the new Federal Interagency Committee on Education.

RESPONSE BY DR. AUGUSTUS B. KINZEL, PRESIDENT, NATIONAL ACADEMY OF ENGINEERING, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

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1. Do you believe it would be useful to amend the National Science Foundation organic act in order to more clearly express a congressional intent for increased attention to research in engineering?

1. I do not believe it would be useful to amend the National Science Foundation organic act in order to more clearly express a congressional intent to increase attention to research in engineering. I believe the purpose can be effected by budgetary scrutiny and emphasis to the Director.

2. It is our understanding that from 20 to 30 percent of the work done by the so-called nonprofit agencies—such as the Battelle, Armour, Stanford, and Midwest research institutes—actually is devoted to engineering that is of a basic nature. Would it not be useful to provide some support for this work through NSF?

2. Support for engineering research of a basic nature should be and is one of the functions of the National Science Foundation. Whether or not the nonprofits should be supported in this area by the National Science Foundation should be determined by the worth of the individual projects which they might propose.

3. In your testimony on July 15, you indicated that the present balance of support between basic research in the physical and life sciences and research in engineering is not satisfactory. What can be done to improve it?

3. Your committee should make it clear that the word "Science" in "The National Science Foundation" includes engineering science and the National Science Foundation should act accordingly. Specifically, the suggestions given in response to item 1 apply here.

4. Considering both that the Department of Defense finds it is supporting about 70 percent of the engineering research on campus and the often stated argument favoring plural sources of Federal support for basic research, what role should the Foundation have in financing research in engineering and engineering education?

4. The Foundation should explore certain projects which are not mission oriented or where the mission does not belong to any specific agency. The aid to engineering education should follow the same principles.

5. What would be the advantages and disadvantages of having the Foundation employ the Academy of Engineering as an operating contractor for undertakings in applied research for which Federal facilities are desirable?

5. There are many projects in which the National Academy of Engineering, and correlatively the National Research Council, could act as an operating contractor for the National Science Foundation. The

prime advantage would be the consideration of the overall problem by dedicated people of eminence, having both knowledge and experience in the specific field. The only disadvantage of which I am aware is that the National Science Foundation would have a less tight control and this might prove to be an advantage in many cases.

6. In your judgment should the engineering profession have more representation in our legislative bodies? If so, what might be done to attract more engineers and scientists into politics?

6. In my judgment the engineering profession does not need representation as such in legislative bodies but it is highly important that members of legislative bodies have education and understanding with respect to engineering. Presently many corporations encourage their people to get into local governmental affairs. I am confident that this is a situation where the country is willing to help those who are helping themselves but that the initiative must come from the individual. For the future I think the most important thing is to have all of our young people given a series of basic science courses so that they are better able to understand the world in which they will live.

7. Considering the Foundation's responsibilities for training and education of scientists and engineers and its interest in the supply, demand, and utilization of this manpower, what responsibility should the Foundation have in studying or doing something about retraining of scientists and engineers whose scientific specialties have become obsolete?

7. There are a great many moves in various directions with respect to "retraining of scientists and engineers whose specialties have become obsolete." I know of no major industrial-education center in the country where opportunities lack. Here again, the problem is to provide incentive to the individual. I think the National Science Foundation might well offer special scholarships for this purpose and might well give grants in support of many of the existent "retraining centers."

8. It has been alleged that some applied field projects that are in the national interest fail to gain support because each agency gives such a project a low priority, although the aggregate of these multiple requirements might warrant a higher priority. What is your opinion on this?

8. Without a specific case in hand it is difficult to directly address the question in No. 8. I presume what is meant is that a subject of importance falls between the slots in the agencies because it is not sufficiently important to any single one of them. It would seem that the Federal Council or the PSAC office could direct such projects to a proper home and that the National Science Foundation should in many cases be the coordinating and supporting agency.

9. What are your views as to the appropriate balance in the conduct of basic research as between universities, the Federal Government, and industry?

9. Basic research should for the most part be conducted in the universities and truly nonprofit research institutions. However, it should be recognized that certain basic research is necessary for the tone, morale, and coupling of any laboratory or organization so we will and should always find an appreciable amount of basic research in industry and mission oriented government laboratories. This should

be considered as an important part of the whole but it should be understood that neither industry nor mission oriented government laboratories should have the prime national responsibility for carrying on basic research. Having said this I would emphasize that financial support for university and nonprofit research organizations who do have the responsibility for the basic research program of the Nation must come from either Government or the general public through direct donation. The latter being as uncertain as it is, the role of the Federal Government in providing financial support is obvious.

10. What proportion of the engineers should have the Ph. D. degree?

10. The question regarding the number of Ph. D. engineers can best be answered by "the more the better." Timing is important. Fifty years ago most chemists who contributed to the science did not have Ph. D.'s. Today there are almost no chemists who have contributed importantly who do not have a Ph. D. degree or equivalent. Given a standard of intelligence and drive the greater the education and training, the more apt is the individual to contribute. If we would assume that the top 10 percent should have this type of education and training and if we assume that there are some 750,000 truly professional engineers in this country, we should have 75,000 Ph. D. engineers. As I understand it, we are so far from this figure that my original reply "the more the better" is the really practical answer.

RESPONSE BY DR. J. HERBERT HOLLOMAN, ASSISTANT SECRETARY OF COMMERCE FOR SCIENCE AND TECHNOLOGY, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

1. What in your judgment should be the relative magnitudes of Federal support for "mission-related" research and general or "free" research, such as that supported by the Foundation?

1. I do not think that any specific formula should or can be established for the Nation between "free" research and mission-oriented research. The magnitude will vary greatly from time to time and must depend upon many factors hard to quantify.

In my testimony of July 15, I stated my philosophy for division of responsibility as follows: "In my view, NSF should not take on responsibility for applying knowledge, or for operating development programs, except in the fields of education and science information."

At another point in that testimony, I said, "The National Science Foundation is a keystone in our efforts to develop the Nation's scientific and technological resources. Its long-term objectives should therefore be focused on the institutions of science, rather than on the solution of specific scientific questions."

The magnitude of mission-oriented research depends first on the public judgment of the importance of the mission. Then within the program authorized by the Congress, wise people must judge the technical opportunities for advancement, in competition with the operating programs that meet short-range objectives.

2. What criteria, in your opinion, are appropriate for the Foundation to use in selecting technical areas for support and determining the national needs for such research support?

2. Any scientific endeavor undertaken by an agency of the Federal Government should be judged objectively on criteria based on the aims of the agency.

In the case of the National Science Foundation, the criteria should be: Does work in this given technical area contribute to the understanding of the world in which we live? Does it foster the stability and growth of the scientific community? Does it produce better qualified scientific personnel? Does it build the institutions of science and technology?

The research supported by NSF should lead to a better understanding of the physical, social, economic, and political world. It should not be aimed at practical objectives of society.

Clearly, in one sense, the NSF work should support the missions of all other agencies' operating programs. Thus, the National Science Foundation should not undertake work which can be better justified by the precisely and properly defined mission of another Government agency.

The National Science Foundation has, in my view, three responsibilities:

A. To support, through projects or grants, the scientific work of individuals or teams of individuals. The adequacy of proposals submitted by scientists can best be judged by the scientific community. The scientific results of their work is the measure of success;

B. To support the establishment and growth of scientific and educational institutions throughout the Nation, to the end that education for science be freely available. The strengthening of resources is the objective;

C. To support certain fields of technical activity declared to be important by those who know the Nation and its social needs best.

For the first two responsibilities, unquestionably scientists meeting the highest standards of their peers are the only ones qualified to pass judgment on the merits of ideas and to allocate moneys. For the latter two, the scientific community must share the responsibility with others of society, as it is unlikely that scientists have an unique competence to make the judgment.

The criteria for the projects to meet the third responsibility should be: (1) Is the area of science now being overlooked but potentially of value to science and to society? (2) Is the area of scientific or technical inquiry of importance either in understanding man's institutions or the world in which he lives? (3) Are there inadequate resources being devoted to the field?

I emphasize projects falling into this category because the NSF has been predominantly concerned with selecting proposals submitted by scientists. It has underemphasized the work which relates to the understanding of new industrial, economic, or social worlds. It has concentrated upon the physical sciences.

3. Do you believe that gaps in applied research may exist between the different programs of mission-oriented agencies? Should there be a Federal mechanism for gap filling in this area as well as for basic research?

3. I am not aware of any significant gaps. Even if they exist, there is no need for "gap filling" by NSF. If NSF meets the three responsibilities described above and concentrates on a better understanding of man and his environment, the mission-oriented agencies will do the rest. Of course, this presumes that all agencies, including NSF, do the optimum amount of R. & D. proper to their missions, and that Congress supplies adequate appropriations.

4. In your testimony on July 15 you referred to basic industrial, economic, and social problems, stating "these studies should be carried out largely in universities where there is presently comparatively little activity." Is this latter statement really true? Our impression is that a good deal of such work is carried on within the universities.

4. Yes, it is demonstrably true. NSF's "Current Projects on Economic and Social Implications of Science and Technology, 1964" (NSF 65–16) lists only 405 projects, or about 4 times the number of the first annual inventory 6 years earlier. It lists projects at only 106 colleges and universities of the more than 1,500 senior colleges and universities in the United States. I call that "comparatively little activity."

Many millions of dollars are being spent by the various agencies of the Government, through the universities, in nuclear technology and atomic power. Similar substantial amounts are being spent in the sciences and technologies of materials.

NSF's support for technical activities related to industrial technology is only a few million dollars. Its support of economics—simulation and model making—is very small compared to its support, for example, of atmospheric sciences.

Look at the technologies of other fields: construction, transportation, communications, highway safety, city building, and the like. Federal expenditures in these fields are minuscule by comparison to nuclear and materials technologies.

Concrete figures are not readily available to document such a statement, but the *a priori* evidence is convincing. I would like to see an accurate survey of the amount of intellectual activity in the universities on the subject of transportation. I believe that it would amount to a few million dollars annually and would be totally unimpressive when compared to the size of the transportation industry and the scope of its problems.

Similarly, the amount of R. & D. conducted in the universities on the science and technology of building construction is insignificant. Yet transportation and building are among the most significant economic activities of the Nation.

Furthermore, the amount of R. & D. conducted in the universities on the subject of automobile accidents is also insignificant. Neither the appropriate Government agencies nor the universities have recognized the magnitude of the problem, despite the fact that 50,000 people are killed in automobile accidents each year. By comparison, polio, which killed a few hundred at its peak, aroused the sympathies of the American people, and a massive effort was undertaken to eradicate polio. Some of the polio money was from the private National Foundation, and some was public through the Public Health Service. Virtually all of it, from both sources, was spent through universities.

Those are some of the types of evidence which convince me that my original statement was true and continues to be true: There is comparatively little activity in the universities on industrial, economic, and social problems relating to technology. I believe that the NSF should broaden its concept of support of science to include greater support of science relating to engineering, technology, politics, and the economy. I further believe that greater support of science and technology by appropriate mission-oriented agencies in the less glamorous fields should be undertaken. Predominantly, the support of NSF should go to educational institutions that combine educational and engineering research functions.

5. It is our understanding that from 20 to 30 percent of the work done by the so-called nonprofit agencies—such as Battelle, Armour, and Midwest Research Institutes—is actually devoted to engineering that is of a basic nature. Would it not be useful to provide some support for this work through NSF?

5. The work supported by NSF should include both research and engineering. The Foundation should support research in the engineering sciences, especially where the funds contribute to engineering education. Only under exceptional circumstances should support

go from the NSF to nonprofit research institutes. The reason is that such institutes are not primarily concerned with education or training, and NSF should confine its attention to universities, which are.

6. How effective is the Federal Council for Science and Technology in presenting, to NSF, the needs of mission-oriented agencies regarding basic research and getting NSF action on such needs?

6. How effective is the Federal Council for Science and Technology of mission-oriented agencies through its various committee activities. I can speak from experience regarding activities respecting the atmospheric sciences. The NSF participates on that committee, considers, and evaluates the scientific and technical programs of the various agencies, in atmospheric sciences, and has modified its program of support not only to insure more scientific workers in the field, but also to broaden its institutional support. It has greatly assisted the development of the scientific literature of the atmospheric sciences. I am confident that the Federal Council also has been effective in presenting, to NSF, problems relating to scientific information and documentation and to oceanography, and NSF has responded by modifying its program.

7. You also said, "For the good of the Nation we must provide mechanisms that broaden participation in the decisionmaking process which determines the support of science and engineering." How do you propose that such mechanisms be provided?

7. The determination of criteria and granting of institutional support, as well as broad support, for these fields of science, must be accomplished through panels and policy boards that represent not only the community of science but also people with political, economic, legal, social, and other experiences.

In the best interests of science, two independent kinds of decisionmaking need to be recognized: (*a*) Decisions related to quality and significance of effort—these decisions are best made by scientists; and (*b*) decisions related to placement and growth of institutions and the broad support for fields of scientific inquiry—these decisions are best made by groups of wise men, including nonscientists. These latter questions of deep social significance require value judgments of the society broadly and should not be left wholly in the hands of scientists.

To this end I also believe that it is possible for Congress to establish mechanisms of review of the appropriations of the various agencies of Government to insure that support both by institutions and by fields of science are adequate and appropriate. More or less piecemeal methods of dealing with individual appropriation requests have tended toward a short-term view and a fragmented approach. While individual appropriations committees can and do provide effective checks and balances on individual mission-oriented agencies' activities, there is no way at present of dealing with the total scientific and technical effort in the perspective of the Nation's needs.

8. How do you distinguish between basic and applied research, and what proportion of total research funds do you feel should be devoted to each, in the context of the Department of Commerce's mission?

8. Applied research is that which clearly has an actual or potential application to meet minimum requirements of the particular institution that supports it. By basic research is usually meant that research whose purpose is to provide an intellectual resource which at a later

time may serve as the basis for application to specific requirements. Judgments of the differences between applied research and basic research, if such differences really exist, will always be subjective and will be largely in the eyes of the beholder. The generally accepted NSF definitions are: "Basic research is that type of research which is directed toward increase of knowledge in science. It is research in which the primary aim of the investigator is a fuller knowledge or understanding of the subject under study rather than a practical application thereof, as in the case with applied research."

It seems to me that a more useful way of approaching the problem of the adequacy of a given agency's proposal is to ask two questions: (*a*) Is the technical activity of the agency adequate to provide the service for which it is responsible; and (*b*) is the scientific activity of the Nation adequate to provide the scientists and the institutions of science which, in the vision of farsighted men, will be necessary to meet the needs of the future? The latter might be called the basic research of the agency.

9. What relations exist between the Bureau of Standards and the National Science Foundation concerning basic research at the Bureau? Based on this experience, what voice should the Bureau and other departments and agencies have in identifying fields of basic research for NSF support?

9. Members of the Bureau staff, in general, maintain close professional contacts with their counterparts on the staff at the Foundation. Reports and information are exchanged through the usual scientific and technical channels. Bureau technical personnel frequently serve as referees on grant proposals to the Foundation. Foundation personnel frequently are consulted by Bureau personnel on matters pertaining to research, likely sources of competent assistance, etc. As a general rule, the Bureau programs do not seek funds from the Foundation; exceptions have been the standard data reference system and areas of information technology.

At present, exchange of information in identifying fields of basic research between the foundation and the Bureau has been excellent. No formal voice has seemed necessary from the Bureau point of view. It should be pointed out, however, that the facilities at the new Bureau site should make university-NBS cooperation increasingly attractive. It is likely, therefore, that Foundation grants at universities could be used to advantage in joint university-NBS research, and it would be desirable to develop a joint Bureau-Foundation policy to promote such activities.

9a. What relationships do or should exist between the Foundation and the Institute of Applied Technology concerning application of the results of scientific research and the development of new technologies?

9a. There has been only a limited relationship in the past since IAT interests are largely engineering oriented as contrasted with basic science. Some special relationships are maintained between certain parts of the Institute. The Clearinghouse for Federal Scientific and Technical Information is discussed in the answer to question 13. The Technical Analysis Division has used some of the statistical information on Government-supported R. & D. The Information Technology Division has, from time to time, had special projects funded by NSF.

10. The point has been brought out during the hearings that certain research projects are referred to the National Science Foundation by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency "X," agency "Y," or both. More specifically:

(a) What guidelines or criteria has the Department of Commerce established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the Department's jurisdiction and, therefore, should or should not be supported by Commerce?

(b) If written criteria have been established, please submit a copy thereof to the committee.

10. I have tried in answering the earlier questions to specify what I believe should be the criteria determining whether a given research project should be funded by NSF or by another mission-oriented department. In either case, the determination should be made in the context of the mission requirements of the agency.

Let me give an example. One the great opportunities for improving the prediction of the weather lies in substantial improvement of the observations of the world's atmosphere. Once an agency responsible for work in the atmospheric sciences has made the decision, it can then concentrate on projects that improve the means by which observations are to be made and by which the data are to be collected, and the computing techniques by which the data are to be analyzed. In addition, the agency will have to sponsor research leading toward further understanding the dynamics of the atmosphere. That is necessary in order for the data to be used effectively in building models which closely resemble the actual characteristics of the atmosphere.

Which agency supports that or any other project? The determination should be made on the basis of the project's relationship to the mission of the agency.

(a) The Department of Commerce has not established quantitative criteria for making that determination. We are influenced by the recommendations of the Commerce Technical Advisory Board, by its panels, and by the technical needs of our bureaus. That is the policy of the National Bureau of Standards and of the Environmental Science Services Administration.

Furthermore, the determination of what work should or should not be undertaken by the Department of Commerce's scientific bureaus occurs through a complicated decisionmaking process, which involves each of the bureaus plus the other offices of the Assistant Secretaries, the Bureau of the Budget, other Cabinet departments, etc. These decisions are based on explicit considerations of the respective missions of the various components. To discuss the process further is difficult because it is long and complex. The important point is that it is very workable.

(b) Written criteria are not available.

11. Have Government-wide standards been established for scientific fellowship awards and stipends? If so, who establishes them and what are the standards?

11. There are no established formal standards. In practice, however, most agency awards follow the pattern set by the NSF. Informal coordination is frequent, and so far as Commerce is concerned, quite adequate and satisfactory.

51-204—65—vol. II——28

12. What would you construe as the proper ratio between project grants and institutional support with regard to NSF?

12. In answering question 2 above, I said that I believe there ought to be three different kinds of programs supported by NSF: Support for the scientific work of individuals or teams, support for scientific and educational institutions, a better understanding of our physical, social, economic, and political world.

At present the institutional support portion of the NSF program, as I understand it, ranges in the order of 10 to 15 percent of its support activities. Project grants and fellowship grants constitute the remaining 85 to 90 percent. I believe that, over the next several years, support for institutions and for new and important fields of scientific inquiry should increase to, let's say, 25 to 30 percent of the NSF expenditures. When that level has been reached, I think the NSF should reassess the problem to determine whether that level is adequate.

This matter is one of value judgment. It is very difficult to arrive at quantitative decisions. I am confident, however, that the present ratio between project grants and institutional support is incorrect; that there is inadequate support for institutions and for new fields of scientific inquiry; and that support for both institutions and new fields of inquiry should be increased.

13. You referred to the Harris bill, H.R. 3420, which pertains to regional science information services that the Department of Commerce might provide.

(a) With respect to section 2(a)(2) on "preparing and disseminating technical reports, abstracts, computer tapes, microfilm, reviews, and similar scientific or engineering information, including the establishment of State or regional technical information centers for this purpose"—Is not the Clearinghouse for Federal Scientific and Technical Information in the Institute for Applied Technology, National Bureau of Standards, already providing these services to interested institutions and persons throughout the United States? If not, what is the difference between the services of the Clearinghouse and those mentioned in the bill?

(b) Section 2(a)(3) of the same bill discussed "a reference service to identify sources of engineering and other scientific expertise." Don't the Science Information Exchange and the Library of Congress referral system provide this service? If not, what are the differences among the various information services that are available?

13. The Clearinghouse for Federal Scientific and Technical Information (formerly the Office of Technical Services) collects, announces, and distributes to the public unclassified technical information from the Department of Commerce, the Department of Defense, Atomic Energy Commission, National Aeronautics and Space Administration, and other Federal sources, plus translated foreign technical reports. The Clearinghouse also provides some other services which are not available elsewhere, such as technical literature searching, using the combined facilities of the Clearinghouse, the Library of Congress, and the Departments of Interior and Agriculture. The Clearinghouse

supplies only information, principally documents, generated from Federal programs.

Documents have their place, but some types of information needed by business and industry throughout the country are not found in documents. Such information may not be related to the basic technical programs having to do with space, defense, or atomic energy, either. It may be unsophisticated information.

The State technical services program, recently authorized by the 89th Congress, goes much further than any documentation activity. Under this program, the States are now identifying their principal economic, industrial, and technical problems and developing 5-year plans for the economic and industrial growth of the respective States. Through local leadership, local initiative, local resources, and local participation, the State-chosen agencies will plan and conduct these programs.

Business and industry need information in addition to that printed and otherwise in tangible form. They also need information that is so new that it is available only in the minds of men. The kind of thing which helps businessmen most is seminars, demonstrations, films, computer tapes, and other tools of an active teaching type, and those will be the techniques most heavily used.

The State Technical Services Act also calls for the establishment of a reference service to identify sources of scientific and engineering expertise. What is intended in this reference service, which is barely being organized now, is the identification of private consultants, research companies, non-profit institutes, or university groups that are knowledgeable on a given technical subject. Any company or any citizen will have access to these names. He can then contract directly with the source of expert help.

Such technical assistance as is provided in the bill is not generally available from any other source in the form in which the Department of Commerce plans to provide it. Thus it does not duplicate either the Science Information Exchange or the Library of Congress referral system.

14. What relationships exist between the scientific and technical information activities of the Foundation and the Department of Commerce? Are they adequate?

14. Dr. Burton Adkinson, head of the NSF Office of Science Information, strongly urged formation of the National Standards Reference Data System and has been one of the strong supporters of the program since its inception.

Dr. Adkinson and other members of his staff are kept informed and hence have a good, broad understanding of our methods of operation and other achievements.

Many of the activities supported by the National Science Foundation are of great interest and importance to the operation of the National Standard Reference Data System. In particular, the proposed program with Chemical Abstracts can aid the accomplishment of the objectives of the NSRDS greatly, especially if it is ultimately possible to identify through Chemical Abstracts the papers and the literature which contain data worthy of further examination. This was one of the objectives in the original Chemical Abstracts proposal to the National Science Foundation, which has not yet been funded.

The Clearinghouse has several activities which exemplify the close relationship with NSF:

(*a*) Under Public Law 480, the special foreign currency science information program of the Clearinghouse is supported by NSF to carry out translation contracts with Israel, Poland, and Yugoslavia. Items are translated at the request of eight major Federal agencies, and the Clearinghouse administers the translation, publication, and distribution of these items. The Clearinghouse also makes these items available to the general scientific community.

(*b*) NSF collects and disseminates information on current research and development in the field of documentation. It supports a Clearinghouse activity for the acquisition, announcement, and distribution of reports relating to this specialized field.

(*c*) The Clearinghouse assists in the evaluation of requests for grants received by NSF in the documentation and information fields.

(*d*) Staff members of the Clearinghouse and the Office of Science Information Services at NSF work together on a number of task forces for the Federal Council for Science and Technology's Committee on Scientific and Technical Information (COSATI) in dealing with technical information dissemination problems. The Director of the Institute for Applied Technology is a member of COSATI.

(*e*) Daily working relationships are maintained. For example, the Clearinghouse Director is a member of the Science Information Exchange Advisory Board, which assists the NSF, as supporting agency, and the Smithsonian Institution, as the operating agency, in matters of policy.

15. What is the relationship of the data-gathering activities of the Bureau of the Census to the work of the NSF in collecting and analyzing information about research and development activities? Are any changes or improvements indicated?

15. The chief work of the Statistical Research Division of the Census Bureau is in the manufacturing sector of the economy, and is conducted for and paid for by the National Science Foundation. No analysis is involved, only collection.

In 1962 and 1963 the Division conducted a survey on occupations in industry. This survey was sponsored by three agencies (including NSF), and was paid for mostly by NSF.

Every year the Division conducts a survey for NSF of industry support of research and development for NSF. These relationships are good, and the Census Bureau has no recommendations for improvement.

16. Exactly how do you make use of the Science Information Exchange?

16. At the present time, except for the Clearinghouse, the National Bureau of Standards makes little use of the services of the Science Information Exchange. The Office of Standard Reference Data does maintain contact with the SIE and is familiar with its methods of operation; some of its contractors use the SIE, especially as a means of locating workers in special fields of activity.

The Clearinghouse and the SIE have a close working arrangement whereby computer tapes of the SIE are available for the Clearinghouse to answer its reference requests. Currently, they are jointly engaged in a new announcement program for telling industry what federally supported research and development is in progress in the physical sciences, engineering, and related technological fields. The SIE is supplying the information, from its computer, which the Clearinghouse will incorporate in its regular announcement journal, U.S. Government Research and Development Reports, used by industry as a reference guide. This provides industry a single source reference both to on-going and completed federally supported research and development.

There is daily liaison between the two agencies, and, as mentioned in the answer to question 14, the Clearinghouse Director is a member of the SIE Advisory Board.

From time to time the Environmental Science Services Administration (ESSA) has solicited from Science Information Exchange its entire file of projects bearing, for example, on meteorological problems. While the file was useful, it was found to be somewhat deficient in certain areas, particularly with regard to the in-house projects of some Federal agencies. We plan to continue use of SIE facilities for information on Government research and development relating to ESSA programs.

17. In respect to getting information on available science and technology support from agencies like yours, how does a science teacher from a small undergraduate liberal arts college go about applying for Federal assistance of specific research and educational projects?

(a) Is there a central organization in Washington available to disseminate the names and locations of Federal agencies upon request of these teachers, or must they search for support by coming to Washington themselves?

(b) Do you believe there should be regional centers established to provide this information?

(c) Or perhaps should a Federal Government representative visit individual colleges annually to give current information to science teachers and to identify projects which would be worthy of Federal support?

17. This is a broad field in which the Commerce Department has no specific responsibilities, hence I prefer not to comment.

18. Please supply additional data on the National Standard Reference Data System in regard to such matters as purpose, scope, size, budget, and method of operation.

(a) How is the work "critically evaluated"?

(b) Is the work done in-house by the Bureau of Standards, or is it contracted out? What is the percentage of each?

(c) How are the compilations produced and disseminated?

(d) Is it available to Government, industry, and private individuals?

(e) Is there any cost for the service? How much?

18. Under the Federal policy statement issued by the Federal Council for Science and Technology, which established the National Standard Reference Data System, this system is specifically identified as one of the components of the national scientific and technical information

systems. The NSRDS is concerned with one part of the entire scientific and technical information problem, that of providing to the technical community of the United States critically evaluated quantitative data on the physical and chemical properties of materials and other substances which are structurally insensitive. For management purposes, this has been set aside as a task to be managed separately from other components of the total system. The NSRDS will be aided greatly by the other components which are now being planned, and in turn will feed its output back into the total system for the benefit of all users. There is no overlap of function. The NSRDS carries out both functions of the entire scientific and technical information system which are concerned with the evaluation and compilation of lasting data on the physical and chemical properties.

Purpose of NSRDS: The specific objective of the NSRDS is to insure that the scientific community has maximum access to critically evaluated quantitative data in the physical sciences and engineering. Its products are compilations of data on the physical and chemical behavior of well-defined substances and systems, evaluated by specialists, and disseminated through a variety of mechanisms so that the data are available to all who need them. The NSRDS is envisioned as the total complex of activities of this type undertaken through Federal agencies, with central coordination, planning, and standardization by the National Bureau of Standards.

The system integrates to a single point of responsibility the present data-compiling activities of the National Bureau of Standards, Department of Defense, Atomic Energy Commission, National Aeronautics and Space Administration, the National Science Foundation, and several other Government agencies. In addition to its assigned responsibility for this type of work within the Federal Government, the system offers mechanisms by which private industry and academic institutions can voluntarily cooperate to solve many mutual problems and answer many common needs.

Data compilation projects have been a traditional part of the NBS program in fulfilling its responsibilities to the national measurement system of the United States. In 1963 the Federal Council for Science and Technology requested NBS to assume a direct role in all Government data-compilation projects and established the NSRDS with NBS as the administrator.

Scope

Functions: The assignment to the National Bureau of Standards by the Office of Science and Technology includes the following tasks:

1. Operation of a National Standards Reference Data Center at the National Bureau of Standards.
2. Coordination of standard reference data activities of NBS, DOD, AEC, NASA, NSF, and other governmental agencies, all of which may operate components of the National Standards Reference Data System, if this is mutually decided.
3. Establishment of standards of quality for various products of the NSRDS.
4. Establishment of standards of methodology, including machine processing.

5. Establishment of standards for such other functions as are required to insure the compatability of all units of the NSRDS.

Technical scope: In order to develop a comprehensive plan of operation, it was necessary first to decide which fields of science and technology should be included and then, in those fields, which kinds of data were appropriate for collection and evaluation. These decisions have been made in general terms by focusing attention on physical phenomena only (that is, no biological effects are included) and by defining "standard reference data" to mean critically evaluated quantitative information relating to a property of a definable substance or system.

Specific definition of the scientific scope of operations of the NSRDS is provided by the list of seven technical areas chosen for initial attention. They are:

1. Nuclear properties.
2. Atomic and molecular properties.
3. Solid-state properties.
4. Thermodynamic and transport properties.
5. Chemical kinetics.
6. Colloid and surface properties.
7. Mechanical properties of materials.

Operational activities: For the compilation of standard reference data, four types of activities are considered to be appropriate in the program of the NSRDS:

1. Data collection and evaluation: Scanning the literature to locate relevant data and background information, exercising critical judgment, and compiling the evaluated data in an orderly format.
2. Preparation of critical reviews: Examination of the status of quantitative knowledge in a special aspect of a technical field, including a survey of experimental uncertainties and limitations and theoretical background, and development of new relationships between properties, as may be appropriate.
3. Computation of useful functions: Derived from standard reference data (e.g., thermodynamic functions), of values of theoretical or semiempirical functions used in the interpretation of quantitative experiments, or of estimated values of unmeasured properties of important substances.
4. Experimental measurements: Determination of experimental values of properties needed to fill gaps in tables to extend the range of a parameter over which a property is measured, or to obtain a more precise figure. (Not to support research merely to develop a new or better measurement technique.)

Size

The size of the National Standard Reference Data System should be considered in relation to the magnitude of the task, expressly considering the present compilation effort, including budgets and size of staff, and the benefits to the Federal budget and the general economy.

Magnitude of the task: The nature of basic research in physical science and technology inherently involves, in most cases, making a quantitative measurement of some property of a material or system. The results of these measurements are very seldom an end in them-

selves. The contribute to an understanding of the structure and natural processes of the world in which we live; they form the basis for applied research; and they are needed for engineering and design activities. In principle, the publication of these data in journals and reports makes them available to those scientists and engineers who need them. In practice, however, there are two major difficulties: first, the great physical effort required to survey the literature to discover relevant data, and, second, the intellectual effort of evaluating the worth of the data.

The rapid growth in quantity of data is indicated. For example, Chemical Abstracts published 1 million abstracts during its first 32 years of operation, a second million abstracts in the following 17 years, and a third million in the next 8 years. It is expected that the fourth million will appear in 5 years or less, with the 1963 Chemical Abstracts listing approximately 170,000 abstracts. Current estimates indicate that the total accumulated volume of scientific information of interest to chemists will double by 1975. The National Science Foundation estimates current research projects now cost an average of approximately $40,000. On this basis, the research reported in 1963 by Chemical Abstracts corresponds to approximately $5 billion.

The fraction of the world literature reported by Chemical Abstracts which is attributed to the United States is estimated to be 25.3 percent of the total; the fractions attributed to the Soviet Union, the British Commonwealth, and Japan have been estimated to be 23 percent, 13 percent, and 7.6 percent, respectively. The increase in the number of papers has been reflected also in a corresponding increase in the number of journals in which technical literature is published. The number of technical journals now being published throughout the world is estimated as high as 30,000. The majority of the useful information in any given field of specialty, however, is normally published in a relatively small number of journals, usually less than 100. But even this number is more than the average specialist is prepared to keep up with.

The task set for the National Standard Reference Data System is to insure that all the data of lasting worth in the literature are collected, critically evaluated, and made available to aid the Nation's progress in defense, space technology, nuclear technology, and other branches of technical industry.

Magnitude of present compilation efforts: Underway in the United States are major projects under the sponsorship of the National Bureau of Standards, the Atomic Energy Commission, several agencies of the Department of Defense, and the National Aeronautics and Space Administration, with lesser efforts sponsored by other governmental and nongovernmental agencies. In addition, important programs are underway in other countries and are, of course, taken into account in the development of the U.S. program. The total world effort is estimated to cover 15 to 20 percent of the available reservoir of data in the literature. In special areas, notably nuclear data, the coverage is considerably higher.

Total Government expenditures in the United States for data compilation projects during fiscal year 1965 are estimated to be about $4 million, of which $1.5 million was disbursed through the NBS Office of Standard Reference Data and $2.5 million from other agen-

cies such as DOD, AEC, and NASA. To cover the available data reservoir in the manner recommended by the advisory panels of specialists who have considered the problem, a total budget approximately five times as great as that now available would be required.

At the present time the staff of the NBS–OSRD consists of 13 persons, of whom 6 have strong technical backgrounds. It is estimated that the size of staff required for coordination and standardization activities plus the provision of a variety of services to the U.S. technical community making use of the stored data would be approximately four times as great. This size staff would be needed in 3 to 5 years if the program develops as now planned. Other agencies would be expected to maintain but not to increase the program management staffs now employed on NSRDS projects.

Magnitude of benefits to the Federal budget and the general economy: The ways in which compilations of standard reference data improve effectiveness and increase efficiency are the following:

1. By providing ready access to quantitative data already determined but not now conveniently available to the user;
2. By reducing duplication of effort in laboratory measurement programs;
3. By reducing the time required by technical specialists in locating and evaluating data which are available, or in fruitlessly searching for data which do not yet exist; and
4. By minimizing the errors in decisionmaking and in engineering design caused by use of inaccurate or inadequately evaluated data.

Estimates of such contributions made by a few of the major compilation projects now in existence indicate the benefits to be 50 to 100 times greater than the cost of producing the compilation. This means that the Nation's research and development program may be penalized by as much as 5 percent by the absence of an adequacy of standard reference data. The purpose of the NSRDS is to reduce that penalty.

Method of operation

The role of the NBS in the NSRDS is that of a "systems manager," and has two operational aspects—input and output. Input takes place in each of the seven technical categories listed previously. The planning and implementation of a program in each of these categories is the direct responsibility of a member of the staff of the Office of the NSRDS at the National Bureau of Standards. This responsibility involves the following steps, many of which are taken concurrently over an extended period. Each category is subdivided into areas of smaller scope listing and organizing in a logical fashion the subfields which in the opinion of specialists comprise the broad category. This step constitutes a definition of the field.

The next step in the development of the program is a survey of the operations of existing data compilation and evaluation groups. This survey determines the technical scope covered, the nature of the output, the number and types of staff required, the financial arrangements, plans for the future, and other relevant information. The help of consultants and leading members of the NBS staff is enlisted in these first steps.

When the field is defined, and some knowledge obtained of the existing activities, the program leader in each area works closely with a panel of consultants, each of whom is a specialist in an appropriate field. The participation of outstanding leaders of the technical community of the United States is sought for these panels. Each panelist is asked to contribute throughout the program. The recommendations of these panels are perhaps the most important factor in the operational decisions made in the NSRDS.

The production of systematic compilations of standard reference data is half the basic task of the NSRDS. The other half is to make these compilations most conveniently available to the user, in the technical community, who needs the data. The Office of Standard Reference Data plans to operate a variety of services, consisting of three main components:

1. Maintenance of a complete file of "Standard Reference Data."
2. Operation of an Inquiry Service.
3. Operation of an Editorial and Publications Service.

The data file is to have a complete collection of all compilations of "standard reference data" produced anywhere in the world, organized systematically and stored for rapid retrieval. The Inquiry Service is to (1) supply replies to specific inquiries addressed to the Office of Standard Reference Data, (2) prepare a current awareness journal which shall contain information about the services available from NBS and about newly appearing compilations of current activities undertaken throughout the world, and (3) operate a variety of other specialized services. The Editorial and Publication Service will have the capability of converting the raw product from a data compilation group into finished monograph, IBM cards, looseleaf data sheets, microfiche, or any other convenient form. At the present time these activities are in the early planning stages; they are to be initiated and expanded as rapidly as the availability of funds will allow.

(*a*) *Critical evaluation of data*

The essential step in critical evaluation of data is the exercise of judgment by a specialist in the field of the data. In exercising judgment, the data evaluator may confirm calculations, apply alternative interpretations, appraise purity of substances, compare data obtained from several sources, and seek explanations for discrepancies. In most cases, the specialist will select a particular value as the most reliable available for the property under consideration.

(*b*) *In-house versus contract projects*

At present, less than 20 percent of the total NSRDS compilation activity is carried out at NBS, and it is planned that this fraction will decrease. Of the total funds disbursed directly by the NBS–OSRD, the in-house and contract fractions are roughly equal, but this ratio will change as the out-of-house effort increases.

(*c*) *Production and dissemination of compilations*

In general, NSRDS compilations that are produced as a result of financial support through the NBS Office of Standard Reference Data are published and distributed through the Government Printing Office. In other cases, a variety of mechanisms may be used, since the

primary criterion is ease of access by the ultimate user. Where an existing project has its own well-known distribution mechanism, no additional mechanism will be used. The distribution channels of other Government agencies will be utilized where appropriate. Distribution by a cooperating nonprofit organization is also under consideration. Private publishing houses have expressed interest in cooperating, but their preference for exclusive rights is difficult to reconcile with the "no-copyright" principle of most Government-supported research. Monographs and books are among the suitable forms for standard reference data. Some data will be made available on punch cards, magnetic tapes, looseleaf sheets, and perhaps through teletype and eventually closed circuit television or other devices.

(*d*) *Availability of products and services*

It is planned that all products and services will be available to all members of the technical community, whether employed by Government, industry, or academic institutions.

(*e*) *Costs for the products and services*

Printed products distributed through GPO are priced in accordance with the usual policies. Other products, such as tapes, IBM cards, and data sheets, will be distributed at prices set to recover the cost of reproduction and distribution. Special services provided by the NBS Standard Reference Data Center (such as computation of special functions, extensive file searching, or special tabulation), will be priced in accordance with NBS practice for calibrations and other similar services.

*19 and 20. Public Law 85–510 empowers the National Science Foundation to conduct a national weather modification program. This act further provides that "other agencies of the Government are authorized to loan to the Foundation * * * such property and personnel as may be deemed useful" in carrying out the weather modification program of the Foundation.*

(*a*) *When will this report be available to the committee?*

(*b*) *Does this action indicate that the Weather Bureau would like to establish its own weather modification program?*

(*c*) *Wouldn't this require specific legislative approval?*

(*d*) *If the Weather Bureau does have the capability in this field, what provision has it made, or what provision does it expect to make, for loaning this capability—that is, property and personnel—to NSF as authorized by the above act?*

(*e*) *In your view should not the NSF continue to support research in this area even though statutory responsibility for conducting a national weather modification program itself might be withdrawn?*

(*f*) *Would you comment on the prospects and problems of weather modification in relation to the statutory mission of the Foundation?*

19 and 20. (*a*) This report has been publishe., and a copy is attached. (The report is in the committee file.)

(*b*) ESSA, through the Weather Bureau, already has an active weather modification program. At present, the main thrust of this program is directed toward the modification of severe storms. ESSA is now formulating the future direction of the program—

to determine where it should be broadened and what the general role of ESSA should be in weather modification. This formulation will require extensive discussions with the Executive Office of the President, with other Federal departments and agencies, and with the National Academy of Sciences.

(*c*) ESSA does not require new legislative authority to conduct a broadened program of weather modification research. It has implied authority for such a program under its general statutory mandate to warn the public of weather hazards, to promote the safety and efficiency of air and sea navigation, and to foster agriculture and commerce. Conceivably new legislation might expressly assign special responsibility to ESSA for weather modification.

(*d*) The National Science Foundation has no weather modification research facilities or capabilities of its own, and it does not itself operate programs of research in weather modification. The primary function of the Foundation in the area of weather modification is to provide financial support for research by others, and the Foundation requires only a few personnel to perform this work. The Foundation has not sought to borrow property or personnel from the Weather Bureau to assist it in its activities under Public Law 85–510. ESSA stands ready, of course, to render such assistance.

(*e*) The Department of Commerce believes that the National Science Foundation is an important link between the Federal Government and the scientific community in the area of weather modification (as in other fields of scientific endeavor) and that this link should be maintained. It also feels that it is important that there be no diminution in principle of the role of the Foundation as a supporter of basic scientific research in the United States. For these reasons the Department would favor having the Foundation continue to provide financial support to basic weather modification research.

(*f*) I believe that assignment of the central coordinating responsibility for weather modification to NSF should be reexamined as the program develops.

21. What additional information would be useful for NSF to collect?

21. The first suggestion would be to make a number of revisions in the industrial categories used for structuring the information on research dollars and manpower. It is not possible, for example, to identify research and development of the building industry from the present categories.

It would be of obvious value to have a measure of privately supported research and development as broad as possible in terms of the number and kinds of firms and institutions interviewed.

The present definitions of basic and applied research seem less useful to those interested in the relationship between research and the growth of technology than they do to scientists. Some categorization which attempted to identify research along the following lines would probably be more useful:

1. Studies designed principally to establish statistical relationships which are not a part of the physical sciences, e.g., how many

college students still work in their hometown? What is the migration pattern of Ph. D.'s by age group, by field, etc.?

2. Studies which are intended to gather information of value to those doing research, but not directly related to research itself, e.g., which universities are conducting research programs on hydrology? What current research projects are being done which should be of interest to the American Society of Civil Engineers?

It would be very desirable if the Foundation also could identify:

1. Research programs designed to advance man's understanding of his physical world for intellectual reasons alone. (Most of this would be in universities and Government labs. So-called industry "basic research" would seldom qualify.)

2. Research done to advance man's knowledge broadly in the medical sciences, excluding drug development if possible.

3. Research done to advance man's knowledge of his social, psychological, or economic world. The extent and nature of most of the work in this area is clearly separable from research in the physical and medical sciences.

4. Research done to find ways of applying scientific or basic engineering knowledge to problems which will not result in manufacturable products, e.g., water desalinization principles, basic fire research, thermoelectric principles.

5. Development of new products as a result of technological advances. This needs to be separated to the extent possible from normal model changes studied to induce consumer demand.

6. Testing of quality and reliability to the extent possible.

22. Do you believe that some applied projects that are in the national interest fail to gain support because each agency gives such a project a low priority, although the aggregate of these multiple requirements might warrant a higher priority?

22. I believe that there are several such fields. Oceanography is certainly an outstanding example. As I testified before the Oceanography Subcommittee of the House Merchant Marine and Fisheries Committee on August 4: "Oceanography is not a unitary concept. Speaking very generally, it embraces two broad areas—the description and prediction of oceanic conditions and the exploitation and utilization of ocean resources. I believe that each of these areas would be enhanced if a single agency were to provide a focus for the activities in that area—and to provide strong leadership for these activities." The remedy may not require centralization in one agency, but it might lie in giving explicit authority to one or more Government agencies to take the lead.

Response by Dr. Herman Pollack, Acting Director, International Scientific and Technological Affairs, Department of State, to Questions of the Subcommittee on Science, Research, and Development

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1. Do you consider science as a tool of international diplomacy? In this connection:

(a) What contributions do international scientific ventures make to our foreign policy?

(b) What have been the effects on foreign relations of scientific research sponsored abroad by the National Science Foundation, the Office of Air Research, and the National Institutes of Health?

1. The intimate connection between the advancement of science and our national welfare makes science an important factor in the development of our foreign policy. It provides in a unique fashion the means for furthering the friendly spirit of international cooperation by broadening the areas of understanding between the United States and foreign countries. Associations generated through common interests in science and technology have added a new dimension to the conduct of foreign affairs. Subjects of such cooperative ventures are weather satellites, desalination technology, medical science, and food preservation. Cooperation in these areas also develop market opportunities for the use of U.S. technical equipment and the international prestige of the United States is enhanced.

(a) International scientific ventures usually relate to undertakings which are beyond the capacity of any single country or which would be facilitated by a multilateral approach. This very pattern of working together with other countries toward mutual goals is a cornerstone of our foreign policy.

(b) Scientific research sponsored abroad by the National Science Foundation, the National Institutes of Health, the Office of Air Research, and indeed also by other branches of the Department of Defense, by the Department of Agriculture, the AEC and other Government and private sources has had a generally beneficial effect upon U.S. foreign relations. It has tended to promote contacts between U.S. technical people and associated political and administrative colleagues on the one hand and their counterparts abroad on the other. The latter often have positions of political as well as scientific and economic significance in their several countries.

The continuing research process in international association accents the mutuality of scientific and technical problems, interests and goals and their extension across international boundaries, building interdependence between the United States and foreign countries that contributes significantly to understanding and to other U.S. foreign policy objectives. This holds true not only for AID-type research sponsorship in certain developing nations but also for U.S.-sponsored

research in technically advanced countries in which we support research primarily in order to obtain results not as easily procurable domestically.

Aside from the intrinsic knowledge gained, U.S.-supported research has tended to enlist the sympathy and interest of foreign scientific communities in the goals of our technical agencies. It has assisted the indigenous research programs of foreign countries, sometimes very significantly as in Israel. Although usually only a small fraction of the total research-support in a foreign country, U.S. funding has often spurred the local governments to increase the amount and flexibility of their own research investments.

Recent cutbacks in U.S. support of research abroad have usually been met both with a measure of regret and with expressions of appreciation and understanding, illustrating the point that these programs have benefited our relations with other countries. Where conditions of research have been difficult, as in NIH work in Ghana, they have stemmed from extraneous political problems. It is evident that U.S. Government research abroad is most successfully conducted, in a diplomatic sense, when local government authorities have full cognizance of the operations in question. When that point is observed, there is no doubt that science generally and U.S.-sponsored research abroad in particular are effective tools in international diplomacy.

2. Following up your testimony of July 20, how does the State Department participate in international scientific ventures of the Foundation? What initiative and control is appropriate to the State Department and for the Foundation in new international ventures in scientific research?

2. The National Science Foundation provides the administrative and backstopping support to U.S. participation in the scientific activities of the OECD and to certain aspects of the NATO scientific program. In addition, it provides comparable services to the United States-Japanese cooperative science program. These activities have been undertaken by the NSF at the behest of the Department of State and are carried on in close cooperation with the Department of State and under its general policy guidance. On programs such as those of the NSF related to the International Year of the Quiet Sun (IQSY), the Indian Ocean Expedition and the Antarctic, the Department of State facilitates the establishment of necessary relations with other participating countries, provides guidance on policy implications and impact of these ventures and, as appropriate, carries on negotiations for other country participation.

The principal control appropriate to the State Department on such ventures is that of insuring that such activities are consistent with U.S. foreign policy objectives and advance the international relations and interests of the United States. Generally speaking, the initiative on international scientific ventures should have its origin in the substantive requirements posed by the subject of the venture. However, there will be increasing opportunities in which the course of wisdom will suggest the use of scientific cooperation and concomitant scientific relationships specifically for the purpose of improving our foreign relations and for obtaining objectives of our foreign policy. We believe that such initiatives should not be shied away from provided there is a sound scientific justification for the proposal itself. In a

related vein, President Johnson stated on August 5, 1965, following a report made to him on a joint project with Korea:

"I believe the language of science offers us new and still largely unstaffed opportunities for international understanding and cooperation. I am hopeful that we may develop an increasing number of joint programs in which the talents of our science and those of other countries can be united in constructive endeavors."

3. Are any scientific research programs overseas supported by the Agency for International Development? Please identify the scope, cost, and foreign countries involved. Does AID coordinate its scientific research support with NSF and with your office?

3. (The following response was supplied by the Office of Research and Analysis, AID.)

AID is supporting scientific research in the less developed countries in a number of different ways:

(*a*) By contracts with non-U.S. institutions for specific research projects. At present, there is one such contract in the area of a research program per se. There are in addition a number of short-term contracts in the nature of surveys, feasibility studies, etc., in connection with specific operational activities. The major research contract is with the International Institute for Educational Planning, a UNESCO affiliate based in Paris.

The purpose of this research is to determine the feasibility of applying the new technologies of education to the problems of the developing countries. The use of such instruments as television, radio, films, recordings, and programed instruction is being assessed in terms of such factors as cost, educational effectiveness, and local conditions. A result of this work, at its completion in December 1966, will be a publication containing guidelines for assessing the feasibility of introducing and utilizing new educational media in developing countries.

Work on this study will go on through the analysis of educational activities in approximately 20 developing countries; since work began only in June of this year, the process of making final decisions on which countries these will be is still in progress.

Chief investigator of this project is Dr. Wilbur Schramm, of Stanford University. An obligation of $190,000 has been made by AID for this study.

(*b*) By contracts with U.S. institutions for research projects in the developing nations. AID carries on a broad program of research on problems of the developing nations, conducted through U.S. universities, nonprofit institutions, and Government agencies. During fiscal year 1965, AID's Office of Research and Analysis obligated $11.1 million for research activity in the fields of agriculture, public health, education, social systems, systems analysis, and operations analysis. Work on the 51 contracts under this program is going on in dozens of the developing nations, in close cooperation with local academic and governmental institutions. Attachment A contains summaries of these contracts.

(*c*) Through support in developing the research capabilities of foreign institutions. A list of major activities of this type is presented in attachment B. (It should be observed that in most cases research is only one function of these institutions.)

AID coordinates its research with NSF, the State Department, and other Government agencies. AID submits an annual report to NSF on its research program. The Office of Research and Analysis receives all NSF research reports, and transmits to NSF all reports emanating from its own activities. The Director of the National Science Foundation is invited to all meetings of AID's Research Advisory Committee, a panel of 16 eminent scientists which approves every project in AID's central research program. And finally, continuing formal and informal coordination goes on between NSF and AID research officers in the particular disciplines.

Coordination with the Department of State is also close. Since 1962, the Agency has maintained an agreement with the External Research Staff of the Department of State, under which that staff, which is highly experienced in this field, provides the Agency with information services covering other research efforts, particularly with special bibliographic searches to detect potential duplication or overlapping research. Further, AID joined the State Department and other agencies a year ago in forming the interagency Foreign Area Research Coordination Group (FAR). FAR was organized with the specific purpose of improving coordination of Government-sponsored research on foreign areas and international affairs. Representatives of the Agency have played an active role in the work of this group. Finally, AID projects will be screened under the procedures now being established by the Foreign Affairs Research Council of the Department of State.

(A representative of AID's Office of Research and Analysis attends weekly staff meetings held in the International Scientific and Technological Affairs Office. The purpose of such attendance is to coordinate the interests of both Offices in the field of international scientific affairs.)

4. What financial and administrative devices have been used in leading scientific countries to support basic research? How do these compare with devices used by the Foundation?

4. In France the Ministry of National Education is responsible for work in universities and in those other institutions mainly concerned with free exploratory research. This includes the scientific laboratories of the 19 universities and the higher scientific establishments, such as the College de France, Ecole Normale Superieure, Musee Nationale d'Histoire Naturelle, Observatoire de Paris, Conversatoire Nationale des Arts et Metiers, Ecole Pratique des Hautes Etudes, Centre Nationale de la Recherche Scientifique (CNRS). The CNRS which is "the main instrument of systematic fundamental research" has a large number of laboratories of its own (10 for physics, 8 for chemistry, 13 for biology, etc.), helps to finance the university laboratories, and acts as the "national training ground for research workers." In 1964 it had 4,500 research workers and 6,300 technicians. About 20 percent of its research workers and half its technicians were employed in CNRS laboratories, and the others in the university laboratories. These 4,500 scientists comprised over a quarter of those employed in the public sector, and an eighth of the total in France.

It is worth noting that fundamental research has fared well in France over the last several years, even as other Government R. & D.

expenditures increased. In 1959, approximately 23 percent of the total R. & D. expenditures of 1,750 million francs [1] was spent on basic research; and in 1962, with the total at over 4,000 million francs, the percent for basic research actually increased slightly.

In 1959 special committees reporting directly to the Prime Minister were set up to select certain "concerted activities" (actions concertees) of special scientific interest and of overriding importance to the community. These were funded by a special fund set up in 1961—the Fund for the Development of Scientific and Technical Research (FDRST)—totaling about 50 million francs per year. The funds were used to place research contracts in the best qualified laboratories with some 50 percent of the cost borne by the laboratory itself. Typical concerted activities are: Energy conversion, exploitation of the seas, molecular biology, cancer and leukemia, functions and diseases of the brain, applications of genetics, animal and human nutrition, population analysis, economics and development problems. In 1963 several more fields were added—more technical in nature—e.g., electronics, automation, macromolecular chemistry, etc.

Thus France is characterized, in gross analysis, by significant Federal support for basic research, in the universities and in the Government's own laboratories. Furthermore, there is Central Government selection of priority fields of study, which receive special consideration in allocation of funds.

Germany

In Germany also, most basic research is carried out in the universities, and in the Max Planck Institutes. Certain regional academies of science, and some supraregional institutions also contribute to the total. Financing comes from the Federal Government, and, significantly, from the Länder, or States, and from industry. The chief avenues for financing are the German Research Association (Deutsche Forschungsgemeinschaft) (DFG) and the Max Planck Gesellschaft (MPG). The former has the legal status of a private association, but secures its financial resources from the Federal Government (44 percent), the Länder (44 percent) and the private sector through the Stifterverband für die Deutsche Wissenschaft (12 percent). The current budget of the DFG 1965 is DM133 million.[2] The contribution of the Federal Government to the DFG is a significant part of the Federal budget for the support of general science. In fiscal year 1965, of DM452 million total, DM300 million went directly to the universities; DM60 million to the DFG; DM72 million to the MPG; DM20 million to other.

The Länder have supported the DFG under the terms of the Königstein agreement, a voluntary pact agreed to in 1949, under which the Länder agreed to support certain scientific institutions which were recognized as having more than regional significance. Besides the DFG, the Länder give support under this agreement to the MPG and to some 30-odd major scientific institutions through Germany (such as museums, astronomical observatories, technical libraries, etc.). In 1964 a new agreement was entered into between the Länder and the Federal Government in which each gives 50 percent of the public funds

[1] One franc equals $0.204.
[2] One DM equals $0.25.

made available to the DFG and the MPG. The Stifterverband (Sponsors' Association for the Advancement of Science) collects funds from trade associations and individual firms, and allocates these to the DFG, the MPG, and to limited other centers. Over the years of its existence from 1949, it has collected well over DM200 million for the advancement of science. Some 70 percent of its funds go to the DFG.

The DFG disburses its funds to the universities in a manner similar to the NSF grant system. Proposals from individual scientists are received, judged by consultants, and approved by the main committee which is composed of 15 scientific members, 12 appointees of the Federal and Länder Governments, and 2 appointees of the Stifterverband. The DFG does not engage in actual research, and maintains no research institutes of its own. It gives support, limited in time and amount, to specific research projects.

The main governing body of the DFG, the senate, consists of 33 leading scientists. It proposes, from time to time, "priority programs," wherein distinguished scientists are asked to participate—i.e., research proposals are specifically solicited. The research proposals are considered as a group, and the program approved or disapproved by the main committee. Some 50 priority programs are in existence at any given time, with support of the order of half a million DM per program. Typical subjects are: soil physics, geochemistry, acoustics, chemical thermodynamics, rheumatism research, botanical photobiology.

The MPG, contrary to the DFG, exists solely to maintain research institutes of its own. The original aim was the establishment of research institutes in which eminent scientists would be free from all teaching responsibilities and could devote themselves entirely to research. Today many of the institutes are linked more or less formally to nearby universities, but the emphasis on pure research remains. The 46 institutes and research centers employ over 3,000 persons, including close to 1,000 scientists. In almost every case the institute director, who is selected for life, is given complete authority in determining the direction of research and controlling the funds of his institute. The work of such institutes is often outstanding, because outstanding men are chosen to direct them, but the coverage of science is by no means complete. The MPG is funded by the Federal Government and the Länder (under the Königstein agreement), the Stifterverband and direct grants, and some of its own receipts. In 1965 the MPG has about DM140 million at its disposal, about 75 percent coming from public funds.

In summary, the basic research in Germany is carried out largely in its 30-odd institutions of higher learning (universities, technical high schools), supported largely by the Länder and to some extent directly by the Federal Government. The DFG subsidizes research projects not financed, or only inadequately financed, by the institutional budgets. In addition, close to 50 Max Planck Institutes produce high-quality work in specific fields. These institutes are likewise largely supported by the Government, but a significant fraction of support comes from individuals and private firms through the Stifterverband. The DFG likewise supports "priority programs," comparable to the "actions concertees" of the French. There seems to be no U.S. counterpart to these devices.

England

The most important site of fundamental research in the United Kingdom remains the universities, and support of their expenditures on scientific research (estimated at about £35 million[3] in 1962–63) comes almost entirely from the Central Government. The most important source is the University Grants Committee (UGC). The Committee advises the Chancellor of the Exchequer of the financial needs of the universities on a quinquennial basis, assessing their requirements on the basis of plans and proposals put forth by the universities themselves and adjusted in the light of national needs and likely available resources. From the funds provided by the Government the UGC allocates block grants to the universities for each of the 5 years. Decisions on the balance between teaching and research, and between various types of research, are made within the universities themselves. In the 1962–63 period, the UGC grants totaled £24 million.

The universities receive further support from the Ministry of Science and Education, in the form of grants from the Ministry's research councils, now numbering four: The Medical Research Council, Agricultural Research Council, Science Research Council, and National Environment Research Council. In the 1962–63 period (when the latter two research councils did not exist but with the now defunct Department of Scientific and Industrial Research in existence), some £6 million was made available from these sources, including £2 million in the form of postgraduate fellowships, and £4 million in grants for research on specific projects. The other channels for support of research in the universities are various Government departments, again supporting specific projects, the Royal Society, industry, and the independent foundations.

Research Councils of the Ministry of Science and Education also support institutes of their own, such as the radio research station, the royal observatories, the geological survey and museum and the like, which also carry out significant fundamental research, but not to the same extent as the CNRS in France or the Max Planck Institutes in Germany. Thus the United Kingdom is characterized by concentration of basic research in its universities, and by Government support for this research both by general grants through the UGC and by "earmarked" grants for directed projects from the research councils.

It is apparent that the National Science Foundation's support of basic research largely through the funding of unsolicited research proposals, is mirrored in other countries, as in the activities of the Forschungsgemeinschaft in Germany. Devices used in other countries which are either absent in the NSF programs, or present to a very small extent, are: the support of university departments as a whole, as with the UGC system in the United Kingdom; the establishment of Government laboratories primarily devoted to basic research, as in Germany's Max Planck Institutes or France's CNRS laboratories; the selection, by the Government, of certain fields of science for priority funding, as in France's "actions concertees" and Germany's "Schwerpunktprogramme."

[3] One pound equals $2.80.

5. During our hearings with the Office of Education, it was stated that AID is funding a study in satellite education or educational TV utilizing satellites.

(a) Can you describe these projects, identify the countries involved and the amount funded?

(b) Does AID support scientific educational projects generally, as distinguished from research projects?

(c) Please summarize the international scientific curriculum adaptation programs funded by AID, including the countries, subjects, and cost. Does AID coordinate these programs with NSF?

5. (The following response was supplied by the Office of Research and Analysis, AID.)

(*a*) AID is not now funding a study on educational TV utilizing satellites, although it has for some time had an active interest in the subject.

(*b*) and (*c*) AID is supporting two major efforts at developing the materials for instruction in science and mathematics in the developing countries. Both are in Africa.

The underlying aim of both programs is to provide the skills necessary for analytic thinking and invention. Results thus far indicate that success in attaining this goal is being achieved.

The first is a program designed to develop new mathematics curriculums for English-speaking African students, through development of textbooks, workbooks, and teachers' guides in the "new mathematics." The materials, which are written primarily by Africans, using examples meaningful to Africans, are designed to develop a new, problem-solving approach to mathematics; $2 million has been obligated for this effort since 1962. At present, over 400 classes in Kenya, Ethiopia, Tanzania, Zambia, Uganda, Sierra Leone, Liberia, Ghana, and Nigeria are using the texts on an experimental basis.

A similar, more recently initiated project, begun in 1965, is in science. The purpose is to develop, for English-speaking African countries, an elementary school science curriculum that will emphasize scientific thinking, as opposed to rote learning, and would teach certain functional aspects of daily living such as sanitation, health, and nutrition. The countries to be involved include all those in the mathematics program plus Malawi, Sudan, and Somali. A total of $485,000 has thus far been obligated.

AID has worked in close coordination with the Division of Course Content Improvement of the National Science Foundation in conducting these curriculum adaptation programs. Dr. Charles Witmer, Director of that Division, sits on the board of project overseers for the programs. In addition, NSF publishes reports of these programs and evaluates the textbooks that are produced.

6. What degree of national responsibility do you consider it desirable for the Foundation to assume for international scientific ventures, in comparison with mission-oriented departments and agencies?

6. It is suggested that the National Science Foundation or some other centrally located executive agency should have the flexibility which would permit it to assume responsibility for worthwhile international scientific activities or cooperative arrangements which find no convenient bureaucratic base in the U.S. Government. This would

be especially useful when there would be a high return to our international relations from the scientific venture.

7. Would you explain the respective roles of the State Department and NSF in selecting foreign students for advanced training in the United States?

7. It is understood that the National Science Foundation does not support foreign students for advanced training in the United States. The Department of State, under its cultural affairs program, does provide scholarships for a limited number of foreign students under the Fulbright-Hayes Act. The nomination of these students is usually handled by binational committees established with certain foreign countries. The final selection of the students for scholarship awards is done by the Board of Foreign Scholarships which is advisory to the Department of State.

8. In what ways and for what purposes does information flow between State Department scientific attachés and NSF?

8. As part of our effort to keep the Department's scientific attachés as well informed as possible about trends and developments in American science, we have arranged for them to receive regularly items such as press releases, annual reports, and special studies produced by several technical agencies of the Government. In this context they routinely receive such materials from the National Science Foundation.

Many of the NSF publications, such as its Research and Development Surveys, its studies on scientific manpower and its annual tabulation of research and development expenditures, are of great interest to foreign government representatives. Our scientific attachés are often the recipients of foreign requests for these studies, or call specific, pertinent items to the attention of their foreign colleagues, and the Foundation has been extremely cooperative in making additional copies available for such presentation purposes. This obviously paves the way for a quid pro quo.

Almost without exception substantive reporting from our scientific attachés is forwarded in the form of State Department airgrams. By an admirable system of subject classification, almost all airgrams of general interest are routinely reproduced and circulated to various interested Government agencies, including the National Science Foundation. That the NSF makes use of these reports in its own appraisal of foreign science programs, in learning of new developments in science education and support abroad, and in evaluating research proposals is evident from the frequent requests made for additional information on specific items, or from comment and appraisal. If the NSF seeks information on a specific subject, the Department will prepare or transmit appropriate requests to the embassies.

9. Exactly how do you make use of the Science Information Exchange?

9. Our use of the Science Information Exchange is almost entirely limited to obtaining information on the current support, from U.S. sources, of scientific research projects in given foreign lands. About two times per year we ask SIE to give us a complete tabulation of U.S.-supported research projects in foreign countries. We are working with the SIE and with other agencies to improve their ability to furnish such a comprehensive picture; e.g., we have encouraged AID to make available to SIE full information on its assistance projects in-

volving science and technology. The alternative is an agency-by-agency count of oversea projects, which is time consuming, liable to inaccuracies, and likely to be incorrect by the time it is completed. More rarely, we have asked SIE for a subject matter breakdown; e.g., a recent request dealt with the total U.S. Government support of reseach on terrestrial uses of solar energy, when such was of particular interest in consideration of a foreign project.

10. Scientific talent in our Government has been concentrated in a few departments and agencies of the executive branch. Do you believe that the scientific disciplines, including engineering and mathematics, should be better represented in:

(*a*) *Our Foreign Service officers overseas?*
(*b*) *The diplomatic corps in Washington?*
(*c*) *Our legislative bodies and elective public offices?*

10. (*a*) The Department of State does believe that the scientific disciplines should be adequately represented in both our Embassies abroad and in the Department in Washington. At the present time the Department of State has appointed scientific attachés to 16 key Embassies abroad. These are individuals with broad scientific qualifications and experience. In addition the Department of State as a matter of policy is encouraging individuals educated in the sciences to apply for appointment as regular Foreign Service officers.

(*b*) and (*c*) The Department of State believes it would be inappropriate and impolitic to comment upon the staffing of the foreign diplomatic missions in Washington. This would also hold true in relation to members of our legislative bodies and elective public offices.

11. Since one principal program of the Foundation is the fostering of new centers of scientific excellence throughout this country, it would be interesting to know how it compares in scope and purpose with the establishment by the West German Government of 40 Max Planck Institutes in that country.

11. The new centers of scientific excellence being fostered by the National Science Foundation and the Max Planck Institutes in Germany were both designed to fashion institutions of outstanding scientific competence. The differences between the programs, however, are more significant than the similarities.

The NSF program is more broadly based than the German one. The 46 separate Max Planck Institutes support isolated disciplines ranging from ionospheric physics to the history of art; from agricultural technology to documentation; from civil law to tissue culture; from theology to silicosis. Each institute is virtually independent, with its own facilities, director, budget, and program. The level of performance in virtually every instance is outstanding, but there is little cooperation or interplay among the individual institutes, with universities or with other research organizations. As a result, interdisciplinary research is sharply restricted and cross fertilization is stifled. Scientific areas not included within one of the institutes suffer from relative neglect, so that there is a series of sharp, high peaks of scientific excellence, but also valleys of mediocrity or inactivity. This shortcoming has been recognized by many German scientists and efforts are underway to modify the level of scientific excellence in a number of allied fields within the same institution. It may support

half a dozen or more departments within a given university so that performance within a broad area of science is raised.

Another difference between the two programs is inherent in their locale. The NSF program is attempting to assist additional universities in attaining scientific excellence. This implies not only the development of superior research capacity but also more effective teaching and training of students.

The Max Planck Institutes stem directly from the Kaiser-Wilhelm Society which was founded in 1911 on a diametrically opposite philosophy. They were established to free outstanding scientists from the "distractions" and "wastefulness" of teaching. Staff members have no teaching responsibilities. They are free to concentrate full time on research. Training of the next generation of scientists is left to the universities. Some German scientists have associated themselves with universities and have voluntarily assumed teaching commitments, but these are still in the minority.

A somewhat related point illustrates still another difference in the two programs. The NSF program attempts to strengthen a department or a division or a group of related divisions. Although a number of professors or senior scientists may be involved, the objective is to strengthen the competence to perform significant research or teaching. Support is not contingent upon the presence of any single individual.

The Max Planck Institutes on the other hand, still operate largely on the "one institute, one professor" basis. An outstanding scientist is chosen and the institute built around him. He operates the institute as a scientific fiefdom with virtual autocratic control on personnel, budget, research programs, and so forth. If he dies or retires or leaves, the character of the institute changes to meet the new director's interest. There is little continuity of program from one director to the next.

The effectiveness of the institute is dependent almost exclusively upon the stature of the director. That it has generally been outstanding is reflected in the catalog of German scientists who have won the Nobel Prize—17 of whom have worked in Max Planck Institutes. The present necessity for scientific teams, however, has diminished the effectiveness of the autocratic scientific giant. Gradually, the traditional pattern in the Max Planck Institutes is changing.

To summarize, the purpose of both programs is similar but the operating philosophies are markedly different. The NSF program seems to offer a broader scope. The Max Planck Institutes have a brilliant history of success but are gradually changing their format.

12. We understand the British Ministry of Education and Science presently is studying the best way to locate new universities and to assign R. & D. funds to them. How closely is the State Department following these studies? Is NSF involved? What information is available, particularly about regional factors in the choice of location?

12. The Department of State is following closely the reorganization of the United Kingdom Government with respect to the development of science and technology.

The present Government sees a very direct relationship between higher education and technical and scientific development. The choice of location for new universities was discussed by Labor Party candidates during the 1964 campaign with emphasis on their intention to

place new universities and technological institutes in areas requiring economic stimulation. As of July 1965 the Ministry of Education and Science was involved in a study of where to locate such institutions and of ways to assign R. & D. funds to them; however, we have no information to date that the study has been completed.

It might also be noted that the Government has announced its intention to create a new institution for scientific and technological education and research in the economically depressed northeast region.

13. The point has been brought out during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency "X," agency "Y," or both. More specifically:

(a) What guidelines or criteria has the Department of State established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the Department's jurisdiction and, therefore, should, or should not, be supported by the Department?

(b) If written criteria have been established by State, please submit a copy thereof to the committee.

13. The only research supported by the State Department is through its external research program of the Bureau of Intelligence and Research. This is a small program, totaling slightly over $100,000 per year. Contracts are concluded with individual scholars or with institutions when a need arises for special information on a foreign area. In view of the small size of the program, and of the fact that the Bureau first identifies a need and then seeks a qualified contractor, it has not been found feasible to establish descriptive guidelines or criteria. A description of the contract program, including a list of typical studies undertaken, follows (attachment C):

DEPARTMENT OF STATE, BUREAU OF INTELLIGENCE AND RESEARCH, EXTERNAL RESEARCH STAFF

POLICY RESEARCH STUDIES PROGRAM, 1962–64

Fiscal year 1962	$125,000
Fiscal year 1963	143,000
Fiscal year 1964	[1] 83,400

[1] Present departmental allocation.

The Bureau of Intelligence and Research was assigned in 1961 the responsibility for starting a program of contract research for policy-oriented studies. The policy research studies program (PRS) enlists the services of social scientists and other experts throughout the country to undertake studies which for lack of time or of highly specialized talent cannot be carried on within the Department. The program's funds also pay for consultants. Many internal studies and reports have benefited greatly from discussions with these outside experts.

When the need arises for special information on a foreign area, the external research staff first insures that the subject has not already been investigated by an individual scholar, a private institution or another agency of the Government. The staff then selects the most qualified scholar in the field and prepares a contract for a study or arranges for consultation.

In some of the long-range studies an outside expert is teamed with an analyst from within the Bureau of Intelligence and Research. For all PRS studies, the external research staff arranges for a project officer from within the Department to monitor the study to insure full utilization of information available in State and to assist the researcher in making the study immediately useful and relevant to the Department.

Most of the contracts have been made with individual scholars rather than with institutions. This approach has made it possible to choose the best available scholars and to avoid the overhead costs that must be included in contracts with institutions.

An unclassified list of studies undertaken since the program began is as follows:

Unclassified Listing of Policy Research Studies, 1962 Through October 1963
(Includes both completed and "in progress" studies)

1. "Communist Internal Warfare and the Security of the Underdeveloped States"—A study of the Communists' increasing use of guerrilla warfare and its political and foreign policy implications. (Fred Greene, Williams College, chief researcher.)
2. "Berlin Policy Paper"—An analysis of the attitudes of our allies toward various political-strategic choices open to Western powers in the Berlin issue. (Arnold Wolfers, Washington Center for Foreign Policy Research, Johns Hopkins University.)
3. "China Study"—An analysis of the adverse effects to U.S. interests if the Chinese Communists should gain entry into the United Nations. (Charles Burton Marshall, Washington Center for Foreign Policy Research, Johns Hopkins University.)
4. "Political Deterrence"—A study of the extent to which political factors might be used to supplement military factors in deterring the Communist bloc from resorting to military aggression in certain vulnerable areas. (Warner Shilling, Columbia University.)
5. "Study of Latin American Political Parties"—A study of the radical parties and the minor leftwing parties and their relationship to the Communists in a Latin American country where the Communists are putting special emphasis on indirect tactics. (Robert A. Potash, University of Massachusetts.)
6. "Demographic and Health Conditions in Communist China"—A study of the population and health conditions in Communist China and their effect on economic, political, and military estimates for that country. (Christopher Tietze, National Committee on Maternal Health.)
7. "Regional Problems in Southeast Asia"—A study oriented toward illuminating some of the major problems common to the countries of this region. (Institute for Defense Analyses, Bernard K. Gordon.)
8. "European Political Integration"—An investigation of Western European attitudes toward the political integration of Europe. (Arnold Wolfers, Washington Center for Foreign Policy Research, Johns Hopkins University.)
9. "Chinese Communist Leadership Study"—A series of studies investigating the structure of Chinese Communist leadership with emphasis on the "second generation" now rising to power. (Donald W. Klein, Asia Foundation; John W. Lewis, Cornell University; John M. H. Lindbeck, Harvard University; Ralph L. Powell, American University—Chief researchers.)
10. "Soviet View of Africa"—An analysis of Soviet writings to determine the current image of Africa, the relationship between Soviet theory and practice concerning Africa, and the degree to which Africans are susceptible to Soviet influence. (John R. Crutcher, University of Notre Dame.)
11. "Political Development"—A study of the political development of a Far Eastern country vulnerable to Communist aggression. Designed to discover ways of strengthening the government against Communist subversion. (Johns Hopkins University—Thomas R. McHale, chief researcher.)
12. "Political Development"—A study similar to that described above on a Latin American country that is particularly vulnerable to Communist subversion. (Johns Hopkins University—Philip Taylor, chief researcher.)
13. "Chinese Communist Power Position Study"—A study of the long-range political problems arising from the shifting power relationships between the Communist Chinese and other Asian nations. (Robert E. Ward, University of Michigan, chief researcher.)
14. "Africa—The Upcoming 'Second' and 'Third' Generation Leadership Groups"—Several studies on the political views and attitudes of the newly emerging African leadership groups. (Douglas Ashford, Johns Hopkins University; William J. Foltz, Yale University; Aristide R. Zolberg, Uni-

versity of Wisconsin; James S. Coleman, University of California at Los Angeles; Donald N. Levine, University of Chicago.)

15. "Sovereign Immunity—Extent of Its Application and Possible Limitations"—A report on the developments in the law of sovereign immunity since 1949. (Joseph M. Sweeney, New York University.)
16. "Chinese Communist Borderlands"—A study of the minority groups in south China and their relationships with the Communist regime and the neighboring countries. (A. Sabin Chase, retired Foreign Service officer.)
17. "North Korean Political Maneuvers"—Studies of the political, psychological, and economic motivations of the North Korean leaders and the interplay of traditional Korean and Communist behavioral patterns and influences. (Evelyn B. McCune, University of California.)
18. "Voting in the United Nations General Assembly"—A detailed study of patterns of voting in the United Nations which indicates the groupings and changes in the voting record over time. (David W. Wainhouse, Washington Center for Foreign Policy Research, Johns Hopkins University, chief researcher.)
19. "A Stabilization and Development Program for Certain Countries Under Communist Threat"—An investigation to determine criteria for effective economic action to support the stability of a southeast Asian country. It pays particular attention to the reduction of any unfavorable impact of possible measures taken by the United States. (Patricia Barnett, INR Consultant in southeast Asian affairs.)
20. "Working Conditions in Africa"—The trends and their implications of African working conditions are studied in an effort to predetermine and therefore prevent Communist exploitation of backward areas. (Elliot J. Berg, Harvard University, and Walter Drew, INR/RAF, chief researchers.)
21. "Potentialities of Regional Organization as a Bulwark Against Communism in Certain Underdeveloped Areas"—A study on the feasibility of encouraging regional organizations as a bulwark against communism in several underdeveloped countries under threat. (Karl Schmitt, University of Texas, chief researcher.)
22. "The Implications of International Monopolistic Practices for U.S. Foreign Economic Policy"—International attitudes and trends toward monopoly industry are assessed and the future role of U.S. industry abroad under such conditions considered. (Corwin Edwards, University of Oregon, chief researcher.)
23. "Attitudes Toward the Sino-Soviet Dispute"—A study of the evolving attitudes of an east Asian country toward the Sino-Soviet dispute. (John C. Donnell, Dartmouth College.)
24. "Politics and Political Parties in the Middle East"—A series of studies which will examine various aspects of Middle Eastern political dynamics as they affect U.S. foreign policy. (Dankwart A. Rustow, Columbia University, and Philip Stoddard, Middle East Institute, chief researchers.)
25. "The Problems of Maintaining National Unity"—This study of a major African nation focuses on the ways and means of strengthening the effectiveness of the government in order to encourage the growth of a sense of national unity. (Merwin Crawford Young, Harvard University and Edward Streator, INR/RAF.)
26. "Political Systems Study"—This study of political organization in a southeast Asian country is planned to provide a political base for economic operations and to provide guidelines for further analysis of local developments. (David A. Wilson, University of California at Los Angeles.)
27. "Effects of Regionalism on World Trade"—The effects on world imports and exports of the growth of international economic cooperation and the implications for the political situation in the countries involved of a further trend in this direction are studied. (Institute for Defense Analyses—Bernard K. Gordon and Donald Keesing.)
28. "Role of Women in the Developing Countries"—The first phase of a study of the changing economic, social and political role of women in the developing countries and its effects on U.S. Government policy. (Constance L. Pierson, chief researcher.)
29. "International Boundaries"—A series of studies giving the background description and an analysis of selected international boundaries in the Middle East. (Lewis M. Alexander, University of Rhode Island.)

30. "Foreign Students in Soviet Universities"—A study of the experiences of foreign students in Soviet universities and the effect of these experiences on their attitudes toward the Soviet regime. (Jane B. Webbink, Harvard University.)
31. "One-Party State Systems"—The first of a series of studies on questions of leadership, organization and political continuity in several African countries with one-party political systems. (Douglas E. Ashford, Cornell University.)
32. "The Foreign Policy of a Major Neutral Country"—A study of the foreign policy of a country which occupies a position of neutrality between East and West. (Karen J. Erickson, Harvard University.)
33. "Students and Student Organizations in Latin America"—A series of studies on the role of students and student organizations in several Latin American countries. (Taylor Peck, USIA, chief researcher.)
34. "The Evolution of a Leading Middle Eastern Political Party"—A study of the origins, ideology, leadership and organization of a leading Middle Eastern political party. (Fahim Qubain, the Middle East Institute.)

Response of Dr. Pendleton Herring, President, Social Science Research Council, to Questions of the Subcommittee on Science, Research, and Development

1. Great advances have been made in the physical sciences in the last quarter century, specifically in atomic energy, to the point where we have learned how to destroy the world—or at least, physically, how to destroy our civilization. The social question is, Have we learned not to?

1. If this question is taken literally, of course, it can only be dealt with in highly speculative terms. However, it does bring to mind a number of points that may be of relevance to the committee. Have we learned not to destroy our civilization? Here we must first analyze the "we" that is involved. Is the reference to the U.S. electorate or to mankind in general? Is the "we" the nations that possess atomic armament or all the nations represented in the U.N.? Is Communist China included in the calculation? Since I am not sure what assumptions the committee may have in mind, I shall not attempt to answer the question in these terms.

I think most of us would agree that there is no readily feasible alternative to the policy of deterrence which in recent years has maintained an uneasy balance in international affairs. The forces that would upset this balance and plunge the world into a cataclysmic war would, in my opinion, be the forces of irrationality or blind dogmatic ideology. The forces that would be more likely to restrain such actions would be those of reason, foresight, and calculation of desired outcomes. Whatever optimized the strength of reasoned judgment would be more likely to prevent disaster. It seems to me that in the nations of the world where education and science are highly valued and where men are free to express their opinions and to hold their rulers accountable, there is the greater likelihood of reason's prevailing. Of course, a host of qualifications surge to mind when one thinks of the errors of the past and of current disorders that call into question such assumptions about rationality. But what hope there is for the future lies, I think, in applying to the conduct of human affairs our full powers for analyzing facts, for facing realities, for choosing those alternative courses of action that seem to lead to adjustment and compromise rather than intransigence and conflict—in other words, attempting to apply to human relationships both the dictates of the ethical norms upon which the great world cultures rest and the skills we have for gathering relevant facts and applying rigorous methods of analysis to social problems and international issues. The social science disciplines are based upon such assumptions, such methods, such habits of thought, and it is necessary that in both the developing nations and highly traditional societies this more analyti-

cal, empirical—if you will, scientific—bent of mind be steadily enhanced. This does not imply that traditions and beliefs appealing to unselfishness and to altruism are one whit less important and needful.

My point simply is that the habits of thought and the intellectual skills that have done so much to order and to control nature for human benefit can and must be further developed and applied much more intensively in dealing with human behavior and social interactions. This has been said many, many times but it has not been said often enough or adequately responded to in the place of most influence: namely, the Congress of the United States.

The social sciences offer a disciplined approach whereby a more accurate picture may be gained of human behavior. It is not a method for producing easy answers but it is a way for arraying the evidence upon which more reasoned decisions may be based. The social sciences can ease the fetters of ideology, lighten the burden of superstition, deepen the understanding of social complexities, and enlarge the vision of human potentialities. These are no small services and if well performed may make unnecessary the facing of ultimate quandaries such as the fate of civilization. There is no end of imponderables, but the United States has gone far in reducing large problems to manageable stages. This is the path of experimentation, of ingenuity, of analysis. It calls for social inventiveness and social engineering. The economist, the sociologist, and the political scientist can help to make more effective the work of the businessman, the administrator, and even the statesman. But the division of labor will remain between the search for knowledge, for facts and theories on the part of the social scientist, and the utilization of these findings in the larger task of formulating and executing public policies.

2. What can the social sciences contribute to an understanding of the personnel characteristics that make some men good scientists, others good engineers, some good economists or businessmen, and equip still other men for other professions?

2. In a review of the over 300 recent research efforts concerned with the predictions of student performance, the findings do not warrant confidence in the predictive value of present knowledge regarding personality characteristics and their relation to academic studies. Not enough is known about personality characteristics to forecast how well an individual may succeed in his chosen career. As we know, some of our most successful leaders did not distinguish themselves in college.

The Russell Sage Foundation has just published "the Prediction of Academic Performance, a Theoretical Analysis and Review of Research," by David E. Lavin, a book that reports on the present state of the literature. In his conclusions the author recommends that, for the future, research be undertaken in a greatly broadened context. Useful predictions of college performance can be made on the basis of high school grades and standardized tests of academic ability, but prediction of college grades based on personality characteristics is particularly ineffective.

We cannot hope for too much in the way of indentification of specific characteristics that make a good scientist, a good engineer, or a good economist without an extensive research effort, because of two major complications. First, each of these categories includes quite a variety of persons, and properly so, for there are many different kinds of jobs

within each. The work of some engineers is almost exactly the same as that of some scientists, while the work of other engineers is hard to distinguish from that of some businessmen. The personal characteristics of a particular engineer may fit him for one kind of engineering duty and make both him and his boss quite unhappy if he is assigned to some other sort of engineering. Second, there are difficult problems in determining how successful a man may be in his job. These problems are particularly complicated in the areas of science, engineering, business, etc., because effective job performance depends upon so many factors and can be expressed in so many different ways.

However, if the committee's question is taken somewhat more broadly, to include all relevant personal characteristics, including intellectual abilities, rather than limited to what is usually regarded as personality characteristics then social science can contribute worthwhile insights as to the nature and distribution of such characteristics. A critical question, as David A. Goslin pointed out in his book "The Search for Ability" (Russell Sage Foundation, 1963), is the degree to which one is able to define precisely on the one hand the abilities (again broadly construed) required for the successful performance of a particular task (whether it be surgeon or airline pilot) and on the other hand construct a measuring device sensitive enough to tell whether a particular individual possesses more than an average amount of the abilities in question. With regard to some professions, for example fighter pilots, astronauts, etc., we have made substantial gains on both sides of the equation. For other professions, including those mentioned in the committee's question, we have some distance yet to go.

To indicate the range of work going on I would call to the committee's attention the following that of: Dr. Donald W. MacKinnon, director of the Institute of Personality Assessment & Research at the University of California, Berkeley; Dr. Donald E. Super at Teachers College, Columbia University; Dr. John Flanagan's Project Talent; Dr. John Holland at the American College testing program, Iowa City, Iowa; and Educational Testing Service's executive study and engineering study.

3. In your testimony on July 20 you characterized the social sciences as having been the "junior partner" in the National Science Foundation's overall program. Do you think they still are, "in spirit" as you said, and will continue so in the future? What steps would you recommend to alter the "junior" relationship?

3. The most fundamental factor in enhanced status is doing a better job. Obviously there is no better way to win deserved recognition. As in all "junior" relationships, time is the chief element in effecting change. To begin with, we must acknowledge that historically viewed as science, the social disciplines have been pursued over a briefer timespan and the greatest advances have been made in relatively recent years.

As already indicated, strengthening these fields must take place in our universities in the first instance. NSF has programs that are helpful and that should be continued. Moreover, the curve of increased support has been steeper in the Social Science Division than in other divisions of NSF. As the dichotomy between natural and social science diminishes and as new interdisciplinary relationships

develop, there will be also, I think, a change in spirit. I think the Foundation still has a large job to do about educating university people, including administrators and others from outside the social sciences, to understand that the NSF does indeed mean all sciences when it says "science."

The time has come for more Federal support for higher education and advanced research across the board rather than for favoring certain fields to the disadvantage of others. I realize that mathematics, engineering, and the hard sciences in general have had need for special attention, that very expensive equipment is often essential, and that vast public funds are indispensable; but now a reexamination of these imbalances seems in order. Federal support that more immediately and financially favors the physical sciences over the social sciences and humanities distorts their competitive relation within the universities.

4. For fiscal year 1964, a total of 2,892 grants were made by the Foundation, of which 246 were in the social sciences. For fiscal 1966, the corresponding figures are 4,300 and 350. Are these considered adequate relative to the support of the social sciences in terms of the funds available to the Foundation?

4. It is not possible to judge the appropriateness of support to a discipline from the number and percentage of project grants it receives; other information is also needed.

The important criteria are the intellectual and other values (including the significance for applied use) of additional knowledge in each area of inquiry together with the feasibility (including the cost) of acquiring new scientific knowledge in each subject area.

A related consideration is the needs of the institutions where research takes place (chiefly the universities and colleges) for financial assistance. It is reasonable for universities to expect assistance from the NSF for their social science activities to approach something like the proportional support they receive for their natural science activities. Support from other Federal and non-Federal sources must be taken into account, of course, but there is no reason to suppose that this would reduce the just claims of the social sciences.

Two factors, however, suggest that the percentage and number of grants for the social sciences might continue to grow:

(*a*) The continuing need to overcome the Foundation's late start in the social sciences generally and in certain of these disciplines specifically.

(*b*) The fact that NSF assistance to the social science research community comes about almost entirely by means of research project grants (and some grants for facilities).

As yet, the Foundation funds for support of national programs and national centers go entirely to the natural sciences. This may well be appropriate at this time, but the result is that in the social sciences project grants must carry a proportionately higher share of the total research support burden.

5. It was argued at the hearings that application of science and technology produces social as well as economic changes. However, the techniques for measurement of the social impact of technology have lagged far behind those for measurement of economic effects. What should the Foundation do to encourage research to improve the measurement of social changes caused by science and technology? What

should be the role of the Social Science Research Council in such a venture?

5. Methods for measuring the social impact of technology are less developed than methods for measuring the economic effects of technology, just as noneconomic measures in virtually all respects are less precise than economic measures. The Government produces through the work of the Census Bureau and a multitude of other statistical agencies a great array of indexes that can be used to indicate change in many aspects of our national life and of world affairs. More recently and with NSF support efforts are being made to develop noneconomic indexes such as opinion surveys and reports on attitude changes.

The Social Science Research Council has encouraged efforts at conceptualizing in theoretical terms the nature of social change and the indexes that empirical inquiry should produce if a dependable grasp of reality is to be attained. Much remains to be done.

A collection of essays, entitled "Social Indicators: A First Approximation," dealing with this question has been edited by Raymond A. Bauer of the Harvard Graduate School of Business in connection with the project for the American Academy of Arts and Sciences on the social impact of space. Here is a document of several hundred pages which is addressed directly to the congressional query. I would be glad to send a copy of this publication to the committee as soon as it is available.

Other studies bearing on the committee's interest are the following: "Technological and Social Change" by F. R. Allen et al. (Appleton-Century-Crofts, 1957) and "Diffusion of Innovations," by Everett M. Rogers (the Free Press of Glencoe, 1962).

6. Which fields of social science do you believe deserve enlarged support from NSF? More specifically:

(a) The present Foundation program in social sciences is divided between cultural and physical anthropology, archeology, demography, economics, economic and social geography, linguistics, political science, social psychology, and the history and philosophy of science. Does this division give satisfactory recognition to the principal social sciences? What changes would you recommend, if any?

6. (*a*) Sociology is also included in the NSF program. NSF support for psychology includes, besides social psychology, psychobiology, which is administered by the Division of Biological and Medical Sciences.

The list is now comprehensive, since many subdisciplines are assumed under these general headings and interdisciplinary work is of course included, except possibly for history. Some research in history is akin to social science research, but some is closer to scholarship in the humanities, and all historians do not agree in regarding their field as one of the social sciences. Support for research in history will presumably be undertaken by the new National Foundation on the Arts and Humanities. In any event, NSF's programs might be extended to include a substantial program in the more scientific historical research. Nevertheless, much work in history will continue to fall outside the sciences. The important consideration, of course, is to assure support from one source or another for good historical research. The

precise role of the NSF should be reexamined after the National Foundation on the Arts and Humanities gets underway.

(*b*) *Would it be preferable to organize the NSF's social science program according to great contemporary social problems rather than by academic discipline?*

(b) I do not think it would be preferable to organize the social sciences program in NSF according to great contemporary social problems rather than by academic discipline.

Not only are the training, interests, and knowledge of social scientists presently organized along disciplinary lines, but most social scientists would agree that in the long run the greatest steps we can take toward solving major social problems would result from advances in our general fund of knowledge regarding basic social processes. Support administered along disciplinary lines is also conducive to stable, long-run support. There need be no inconsistency between the present form of organization and special Foundation efforts to support research that is likely to be urgently needed for solution of particular social problems when this is necessary and when other Federal agencies do not have responsibility for this kind of assistance.

There can be a reasonable expectation that out of efforts to study realistically great social problems basic advances in knowledge can sometimes be made. I personally question the puristic attitude that deplores involvement in contemporary problems in the name of "basic research." The opposite hazard to be wary of is the tendency of some investigators with a strong reformist bent to confidently offer solutions and panaceas on the basis of inadequate evidence, superficial understanding, or wishful thinking. Task forces composed of interdisciplinary teams can give attention to special problems. They can proceed on an ad hoc basis, regrouping and recombining skills as the task in hand may require.

(*c*) *What advisory mechanism would you recommend to guide and assist the Government, including the Congress, the President and his scientific officers, and the Foundation, in identifying fields of social science for support and the levels of support amongst them?*

(*c*) To answer this question responsibly and realistically would require extensive discussion and consultation among the individuals and organizations that already have some measure of concern with the many issues involved. This calls for skillful staff activity over a period of months. My preliminary opinion is that much can and should be done to clarify the relationships of social scientists to the Federal Government and to enhance the contributions that their disciplines could make.

One pattern is that of the Council of Economic Advisers. Another incipient effort is that of the Social and Behavioral Science Division of the National Research Council of the National Academy of Sciences. The Brookings Institution has an outstanding record of advice to the Government. The services offered by the several social science professional associations with offices in Washington are helpful. Much is being accomplished on a day-to-day, ad hoc, opportunistic, decentralized basis. Whether more formal relationships, with greater visability and concerted leadership would be more effective, calls for study. Such a move might or might not prove efficient and fruitful. Well directed and financed, I think, a conspicuous agency representa-

tive of the social sciences and in close contact with governmental agencies and university social scientists would both aid officials and accelerate the development of social science research. For the social scientist to be simply called in as a consultant or treated as a grantee tends to limit or subordinate his intellectual contribution to the purposes of the governmental agency.

7. In your testimony you mentioned how the Foundation had to gain the trust of social scientists before they would turn to it for support. Does this imply alternative sources of support were available? If other funds are available, why should the Foundation consider extending its social sciences program?

7. In my testimony I was referring to the period when the Social Science Division was just getting established and gaining visibility. Research has almost never been solely dependent on public bounty; private philanthropy has normally provided the risk capital and the Government has stepped in at a later stage. Thirty, 20, even 10 years ago the great private foundations were directly supporting the social sciences as such. Today a number of very able social scientists do get support from private foundations for special projects, but the Federal Government is the most significant source though often under rubric of defense, space, health, education, international aid or relations, or some other major policy area. The NSF is the agency formally and avowedly supporting basic research in the social sciences.

8. What should be the respective roles of the Foundation, the Office of Education and the Social Science Research Council for education and training of scientists in the social sciences?

8. Under the existing administrative organization the Office of Education's responsibility for NDEA fellowships and the NSF program of training fellowships in the sciences seem satisfactory. Should there be a strong and separate Department of Education capable of providing research support and aid in graduate training in all fields, then the role of the NSF might be reexamined and perhaps modified. These relationships are too complex to admit of a categorical answer. The Social Science Research Council is prepared to review its own functions and objectives in the light of current governmental concerns with education and research.

9. This being the age of the scientific revolution, in what ways could the Government further educate the general public about science and technology? How much emphasis should the NSF give to research into the ways and means by which scientific discoveries are put to use?

9. There is already such a vast amount of information available to the general public about science and technology that I see no reason for the Federal Government to devise special programs to this end. As education is strengthened at all levels through Federal help the oncoming generation will be better prepared for the age of the scientific revolution.

The NSF through its concern with the history of science might well support inquiries "into the ways and means by which scientific discoveries are put to use." The Foundation can and now does support some research of this kind, including research by social scientists. It should support as much good work as it can find on the basic processes of diffusion of scientific knowledge and similar phenomena. It is

probably not the appropriate agency to "promote" the practice application of scientific knowledge.

The Foundation does expect scientific findings from research it supports to be published in the normal journals and other channels of scientific communciation.

10. Has the Social Science Research Council ever made use of the services of the Science Information Exchange? Have you contributed information to the Exchange?

10. No. We have not had occasion to make use of the services of the Science Information Exchange. Whatever information we have that may be pertinent is available to the Exchange.

RESPONSE BY DR. WALTER O. ROBERTS, DIRECTOR, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

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1. In your testimony on July 21 you spoke of man possibly altering the atmospheric environment to his detriment. How crucial is this problem? Is it an immediate danger? Do you believe the public realizes the problem?

1. In the July 21 testimony, two separate dangers were discussed. The first is that man is already altering his atmospheric environment in ways that may have long-range and widespread effects of which we are not now aware. It is clear that the growth of urban centers, the increase of general use of fossil fuels, and the more extensive tooling of soil, particularly in marginal rainfall areas, has altered the burden of dust and waste gases in the atmosphere. Many of the influences of these wastes are detrimental. The detriment is not only to the health of people and plants, but also to the cleanliness and comfort of life in population centers. The dangers of this kind of alteration of the atmospheric environment are immediate—the results are with us now, and the future can only see the progressive worsening of this problem, unless very major measures are taken. I am not sure that the public realization of this problem is in pace with the growth of the problem. Some gases like ozone and some of the nitrogen compounds can, under certain circumstances, be serious health problems.

What more widespread effects there may be—for example, from the apparent significant increase in carbon dioxide in the global atmosphere, put there by exhaust from fossil fuels—are as yet unknown. It has been theorized that the effect may be sizable, but no one can say with certainty today. The only prudent course is to undertake necessary research to understand the full effect and to assure that no adverse, irreversible processes will inadvertently be touched off.

The other danger is that large-scale weather and climate modification experiments may be tried in nature before their full effect can be predicted, and that damaging inadvertent modifications may therefore result. Further research is necessary before it is possible to give an unequivocal answer to the magnitude of this possible detrimental alteration. One can speculate that if large-scale modification of continental climate can be accomplished to the benefit of one region, there is possibility that it will simultaneously be to the detriment of another: or if one segment of the economy is benefited by increased rainfall, another may be damaged by this, even in the same region. Here the public perhaps fears the consequences even more than the realistic possibilities suggest may occur. But it is a realm of science in which speculation should be replaced by solid knowledge.

2. You stated that organizing and setting up the experimental global observing network such as was described to the committee by Dr. Hollomon is an enormous administrative and engineering task, requiring complex cooperation on both a national and international scale, and that the logical agency to manage such a program is the U.S. Weather Bureau. You also said that this type of information is essential before a large-scale weather modification scheme is attempted.

(a) This being the case, should the same government agency be responsible for both weather prediction and weather modification, or can these two functions be separated in any practical manner?

(b) How do you see the role of NSF in this regard, considering that it is charged by statute with a weather modification function?

(c) What should be the role of NCAR?

2. The importance of this network cannot be overestimated. Detailed information on a global scale is essential before one can accurately simulate, in an electronic computer, large-scale weather modification schemes. Once we have accurately judged the total effect on any large-scale weather modification scheme, the global data will help optimize the timing and controlling of large-scale operations. (We do not now know whether such operations will be successful; but if so, the global data will be essential to both the research and the operational stages.) Of course, the usefulness of adequate observational coverage of the entire globe for weather prediction is obvious.

(*a*) It seems clear to me that the U.S. Weather Bureau is in the best position to represent the United States in the operation of a global observing network, and to provide weather prediction. As for separating weather modification and prediction operations, it seems that one could, in principle, conceive of a practical manner of separating them. Since large-scale operational weather modification is several years away, at least, there is time for the Government to determine how the responsibilities of the United States as a whole, and of various agencies, would best be served. This will depend, to some extent, on what purposes are selected for weather modification, and the interest of the agencies involved. This, in turn, depends on what large-scale weather modification possibilities turn into realities.

There are, however, some shorter term weather modification possibilities (on which both the Weather Bureau and the Bureau of Reclamation are doing what might be termed applied research), and in which some overall governmental determination of responsibilities may require more immediate attention.

(*b*) Perhaps the salient point underlying an answer to this question as a whole is that a period of years will be required for basic research and for simulation of various large-scale weather modification schemes before any operation should be attempted. The NSF should play a central role in this research phase, and is particularly well situated to carry out the program of annual evaluation assigned to it by statute. A natural extension of this role would be to help bridge the gap between new knowledge and its application. But when the time comes for operations, the operating agencies should be in charge.

(*c*) As explained in my written testimony, NCAR's role in the atmospheric sciences is primarily directed at basic research; but, as the

trustees of the University Corp. for Atmospheric Research made clear in a resolution passed last April, our role also includes promoting the linkage between research and applications. Given the structure of U.S. science, this means promoting the linkage between university research and the long-term interest of various operating Federal agencies. As this complex role develops, NCAR can increasingly serve as the interface, helping to muster the strength of the university research community toward the solution of the many, complex basic research and developmental problems involved in a thorough investigation of the various possible modes of weather modification. (And I should point out that this includes many things beyond just cloud seeding to increase rainfall. Indeed, in the long run, this may turn out to be a relatively minor weather modification method—but the "long run" is difficult to predict.)

3. Is any work being done today on the supercomputer that you discussed? What do you think the cost of developing such a computer would be? Who do you think should properly undertake it?

3. The computer I described is one that a committee headed by Dr. Jule Charney of MIT recommended in a draft National Academy of Sciences report as being essential to both operational and research use of the data derived from the global observing network discussed in my answer to question No. 2. No specific work is now being done except informally by various groups (including NCAR) as to what the rough scientific demands on the machine might be.

In my own view, I feel that it would be ideal, providing it is feasible, for the cost of developing such a computer to be shared between industry, private foundations, and the Federal Government. The development work could very properly be guided by the NCAR scientific staff, in cooperation with university and other research personnel. The actual computer design and development must be undertaken by industry, with NCAR representing the potential customer interest—to make sure that the computer is properly designed to do the things that the users will want it to do. It is clear in my mind that the ultimate value to the Nation of a supercomputer is clearly justified as a major research tool to have it built at Federal expense. However, I would hope that these costs might be shared with other segments of the Nation.

4. You mentioned that large-scale weather modification schemes will necessarily be global in nature and are "likely to be international in consequence." What diplomatic or political repercussions do you foresee in such a program?

4. Because the atmosphere knows no national boundaries, it is clear that modification of the atmosphere in one country may well affect the climate, weather, or air pollution problems of another. And the larger the scale of modification, the surer it will be that we are confronting a problem of international character.

Indeed, it is clear that air pollution originating over one country is already affecting the atmosphere over another. This is spectacularly noticeable in Western Europe. If one succeeds in diminishing the intensity of hurricanes to the advantage of one country, one may adversely affect the available rainfall in still another. It is easy to see how conflicts of interest in weather could develop between nations. Such diplomatic and political repercussions have been foreshadowed

by the kinds of discussions that occur in respect to upper atmosphere modification (for example, the U.S. atomic tests in the very high atmosphere, which clearly modified the radiotransparency of the upper atmosphere). As a result, a few years ago the International Astronomical Union condemned the U.S. nuclear testing in the high atmosphere on grounds that it interfered with radio astronomy research.

Even if the possibilities are scientifically on weak ground, there will be fears that hail suppression in one country will result in decreased rainfall in another, etc. As a consequence I can see many diplomatic and political repercussions unless a great deal of the development—and perhaps the actual conduct of weather modification operations—are conducted under international auspices. The time is now, when large-scale international weather or climate modification is still mainly a scientific problem, that international mechanisms of cooperation must be forged. The closer we get to applications, the more difficult it will be to begin forging these ties.

5. You also indicated in your testimony that you are happy with NSF's support of NCAR, and that there is an excellent working relationship between the two. Dr. Hollomon, in his testimony before the committee, stated that "the support of NCAR should not be the unique responsibility of NSF," and he inferred that it should more properly be associated with the Environmental Science Services Administration. Would you please comment?

5. The intimate association between NCAR and the NSF is directly linked to NCAR's central responsibility to promote the development of basic research in atmospheric science, and its important related mission to support the growth of research and advanced teaching in the atmospheric sciences in the university community.

Because of this close association with NSF and with the university community, NCAR is also in a unique position to promote the linkage between the university community and the agencies; that is, between the basic research capability essential to progress in this field and the needs of the mission-oriented agencies.

This does not mean, however, that NCAR will not be properly and deeply interested in cooperation with ESSA. As a matter of fact, cooperation already exists between NCAR and the Central Radio Propagation Laboratory (soon to be affiliated with ESSA) in high-atmosphere research, and with the Weather Bureau (now associated with ESSA) in other areas.

Dr. Hollomon's view, as I understand it, is that the work of NCAR has such relevance to the operational mission of ESSA that the resources of the laboratory should be to a substantial extent available to ESSA upon call. He feels that only through support of NCAR can ESSA feel free to call upon the services of NCAR scientists in support of various appropriate ESSA missions.

It may well be appropriate, in the near future, for a division of NCAR's activity to be more directly concerned with applications of the atmospheric sciences. As this effort develops, the activities of the division might appropriately be supported by the Federal agencies that will call upon it in connection with their own prime missions.

But in the broad research and educational mission of NCAR—its principal goals at the present time—it seems to me that single-source

funding is the most controllable and the most efficient mode of NCAR funding. And NSF clearly is the most logical funding agency.

6. To what extent does NCAR function as an NSF laboratory?

(a) What controls does NSF exercise over—

Selection of projects and funding for them? Approval of subcontracts and orders?

Review and approval of construction projects for major plant and equipment?

Salaries and wages of NCAR staff? Reporting of results of NCAR research?

(b) Does NSF have title to all of the plant and equipment, or is title assigned to the agency that supplies funds for a particular time?

(c) What is the duration and character of the University Corporation for Atmospheric Research contract with the Foundation for the operation of the Atmospheric Research Center? Is this contract reviewed periodically? How far ahead does your commitment of funds run?

6. **NCAR** is an independent laboratory, operated by a nonprofit corporation composed of 21 universities. Its sponsorship and principal budgetary support come from a contract with NSF. We view our relationship as a partnership in pursuit of goals arrived at through a historical process in which the atmospheric sciences community as a whole has continually played the most important role. NCAR's program and plans are reviewed by various mechanisms drawing mainly on the university community.

Each year NCAR, with the endorsement of UCAR, presents its budget request to NSF, spelling out in broad detail its plans for research, facilities, and other activities. At this point, NCAR enters NSF's budget procedure, and its final fiscal allocation under its NSF contract depends on deliberations between NCAR and NSF, between NSF and the executive branch, and between NSF and the Congress.

In addition, we informally tell NSF of the results of our various review mechanisms, in order to assure NSF that NCAR's plans are continually responsive to the needs of the atmospheric sciences community and to the national interest.

With specific reference to the subquestions:

NCAR's program is developed through the mechanisms described above. NSF reacts to these plans. NCAR's budgetary allocation is the product of NSF's reaction to the plans and of NSF's own appropriation level. Once a fiscal-year allocation for NCAR is determined, NSF allows NCAR considerable latitude in determining how the funds shall be used to meet the program goals described in NSF's budget request on behalf of NCAR. NCAR submits an annual financial plan to NSF for approval after its allocation is received.

NSF approval of subcontracts is required for all cost, cost plus fixed fee, and time and materials subcontracts over $25,000. NSF review is also required for subcontracts for architectural, engineering, and construction subcontracts regardless of dollar amounts.

With relation to construction contracts, NSF requires that it be given at least 7 days' time for review of each subcontract involving construction work; unless NSF advises us to the contrary within that period, we may proceed.

NSF must also approve (*a*) subcontracts or leases for real property, aircraft, printing equipment, and other items the purchase of which is restricted by the Government; (*b*) subcontracts or purchase orders that have a "hold harmless" clause in favor of a third party.

These restrictions apply, of course, only to subcontracts for which NSF contract funds are used. For example, UCAR's own private funds have been used for a construction project this summer at the Climax Observing Station, near Fremont Pass, Colo., the site of which UCAR holds on a long-term lease from the American Metals-Climax Corp. We have, of course, informed NSF informally of this project—an extension to one of our observing-dome buildings.

NSF requires its approval of all salaries in excess of $17,500. A total amount for salaries is, of course, contained in NCAR's annual budget request and financial plan.

Reports of research results are usually published in the scientific literature. NSF requires no specific report except for a brief annual summary. However, NCAR's scientific production is reviewed by university-oriented groups, and NSF satisfies itself by informal means that these reviews are sound and thorough.

NSF has title to all the plant and equipment purchased, or developed, out of NSF contract funds. In addition, UCAR owns some $2,015,063 worth of capital items, and the following values are assigned to equipment developed in the past under contracts with three Government agencies: Air Force, $248,769; Navy, $184,224; NASA, $9,803.

The current contract between UCAR and NSF is a 5-year contract signed June 1, 1960. Prior to its expiration on May 31, 1965, a 6-month extension was signed, and it is expected that an additional similar extension will be agreed upon. Meanwhile, discussions of a new 5-year contract are now getting underway. Commitment of funds is a fiscal year at a time.

7. How is the basic research of NCAR related to the mission interests of the Federal agencies interested in the atmospheric sciences?

7. I assume the answer sought here is aside from the support of basic research in the physical sciences that will produce knowledge useful to the mission-oriented agencies—this, of course, is the justification for the basic research support these various agencies supply.

In the atmospheric sciences, basic research problems present major obstacles to progress toward applications of interest to every potential user agency. At this stage of the science, therefore, basic research progress in general is in the direct interest of all the agencies.

In addition, as stated previously, we are now considering various mechanisms to promote the linkage between basic research—at NCAR and in the universities—with the interests of the user agencies on the application of new basic knowledge being produced. Communication lines between NCAR and various other agencies are, in my opinion, actually quite good, and can serve as a firm base for a more focused effort.

8. What is the distribution of financial support for NCAR among the various Federal and non-Federal sources? What understanding exists about the duration of Federal support?

8. Virtually all of NCAR's operating funds at present come from Federal sources. However, UCAR carries on certain activities—for

example, a fellowship program—which are related to the same goals as those of NCAR, but are supported with private funds. It is UCAR's firm conviction that a modicum of privately supported activity helps protect the independence and university-community orientation of NCAR.

So far as an understanding with NSF about continued support is concerned, there is no formal guarantee, of course, beyond a given fiscal year. So long as NSF is persuaded that NCAR is an effective means of promoting progress in atmospheric research, we expect that NSF, within its own overall budgetary limitations and obligations, will continue to sponsor and support NCAR—but no longer.

9. Has NCAR ever experienced conflicting expressions of interests from Federal agencies funding its operations? If so, what was the role of the Foundation in resolving such conflicts?

9. We have not really had any conflicting expressions of interests. People are often impatient for NCAR to undertake many things that it has not had time and support to undertake, or that it does not have adequate manpower to undertake, but this is quite normal in a developing effort.

10. The point has been brought during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. Specifically:

> *(a) What guidelines or criteria has NCAR established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of your center's jurisdiction and, therefore, should, or should not, be supported?*
>
> *(b) If written criteria have been established, please submit a copy thereof to the committee.*

10. As described previously, NCAR program plans are generated by NCAR itself, rather than referred to NCAR by NSF; nor does NCAR advise on the propriety of projects among Federal agencies. This does not mean, however, that NCAR's research and facilities programs are not responsive to needs of the scientific community, and it has a number of internal and advisory mechanisms for monitoring those needs.

11. What is NCAR's policy concerning cooperation and collaboration with colleges and universities in basic research in the atmospheric sciences? How many visiting scientists are in residence at NCAR now? Of these, how many are working on projects that they have brought with them?

11. NCAR strives in a number of ways to achieve a thorough interaction among scientists from NCAR, the universities, and from other research groups. During the past year NCAR has had 34 scientific visitors in residence for periods of 4 months or more, as well as 166 for briefer periods. Other modes of interaction with university research programs are: (1) NCAR sponsored or hosted conferences to review results and plan future research in various fields; (2) the activities of the NCAR Facilities Division, which provides joint-use facilities in aviation, computing, and ballooning, and serves as national spare parts supplier to university-based M–33 radars; (3) the NCAR

"affiliate professorship" program, in which NCAR scientists and universities conclude 3-year agreements allowing the scientist to participate in teaching and other academic affairs on a part-time basis, and to be in residence for at least one semester during the 3 years; (4) a steady program of briefer visits to universities and colleges to give lectures or seminars; (5) summer employment of students in NCAR scientific programs. In addition, NCAR provides, from private funds, fellowships for graduate students to study at universities of their choices; and they are employed in NCAR scientific programs the summers before and after the year of fellowship study.

Scientists who visit NCAR may work on their own projects or participate in the work of an NCAR research group. Of those who do one of these, the latter predominates; but most do both. It is worth mentioning that they also often take back to their universities ideas for research projects which were generated while at NCAR.

12. What role is NCAR playing, formally or informally, as a training ground for new scientists and technologists in atmospherics?

12. Part of the answer to this question is provided in the answer to question No. 11. In addition, NCAR conducts a program of postdoctoral appointments for scientists who have received the Ph. D. in meteorology or in an allied basic discipline—chemistry, physics, mathematics, et cetera. Some of NCAR senior staff members have also come from these fields. One of the reasons for NCAR's existence is to help bring the atmospheric sciences more closely together with the basic disciplines, in order to broaden the field and make its attacks on problems more rigorous and comprehensive. In its interactions with universities and colleges, this broad view of the atmospheric sciences is being promoted in the ways described in this and the previous question.

13. You testified that "the heart of our country's basic research is in the universities." Do you see any danger of turning our colleges—that is, their science and engineering departments—into great research laboratories, at the expense of education?

13. There are dangers, but most universities are well aware of them, and this in itself is a help in combating them. To some extent, the need to create major facilities in order to carry on research contributes to these dangers. NCAR's facilities, created for the joint use of university researchers, help relieve some of the pressures in the atmospheric sciences.

14. Exactly how do you make use of the Science Information Exchange?

14. Our librarian informs me that NCAR, as an institution, does not make use of the Science Information Exchange.

15. Should NSF assume a more active role in the support of international science programs and projects? Might not U.S. aims, other than the development of pure science, be furthered thereby?

15. The prime objective of NSF should be the development of basic science in the United States. In many cases, however, NSF-supported activities in pursuit of this aim in the international sphere. Examples are the support NSF has given to activities of the International Geophysical Year and the International Years of the Quiet Sun. These ventures not only promoted good science, but undoubtedly served broad U.S. interests as well.

16. Do you see any advantage in efficiency of operation if NCAR were operated by a profit organization or as an in-house laboratory of the Foundation?

16. No. Our linkage to the university and basic research community is maximized through the present arrangement, and gives us a unique position from which to help relate basic research to application. In addition, the existence of UCAR allows us to undertake various activities promptly that might be delayed or prove impossible if there were not a minor source of private funds.

17. What contribution have the small college and the young unknown investigator to make toward the betterment of science? What specific effort does NSF make to assist them and take advantage of their potential?

17. A comprehensive answer to this question can be better supplied by NSF. NCAR's activities include the forging of ties with small, liberal arts colleges that do not have atmospheric science courses, in order to acquaint bright young science students with the opportunities and challenges of the field. It is clear that in this expanding field of science, small colleges and universities must contribute to the need for manpower.

As for the young, unknown investigator, every scientist of renown was once young and unknown.

18. What agency of Government, if any, has responsibility for the coordination of Federal research and development in the three fields of air pollution, soil pollution, and water pollution? Is such coordination a proper role for the National Science Foundation?

18. I am not familiar enough with the specific activities and plans of the various agencies to shed much light on this question. A definitive recommendation would be the product of a long, intense study.

RESPONSE BY REV. THEODORE M. HESBURGH, C.S.C., PRESIDENT, UNIVERSITY OF NOTRE DAME, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

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1. As a university administrator, are you satisfied with the balance of Federal support given to project grants, institutional grants, and science development grants? How would you attempt to reach an optimum distribution of funds for such support?

1. In general, I am satisfied that the National Science Foundation is trying to achieve an optimum balance. As more centers of excellence are developed, there will be a need for more project grants. This is not a straight line development. Large sums will be needed to improve 50 to 80 universities. Once they reach the higher level, there will inevitably be more demand for fellowships, traineeships, project grants, etc.

2. Is the level of support for social science grants adequate? Might not the percentage of the National Science Foundation's budget going into this area be increased?

2. Social science support has been growing. I do not believe it has yet reached a plateau where it might level off somewhat (not absolutely). I believe it should continue to grow rather rapidly until this whole area is better developed.

3. Considering the large increase in Federal funds for basic research at colleges and universities and the extension of that support into the social and behavioral sciences, what problems may confront the colleges and universities in retaining their independence?

3. Universities must guard their independence as they guard their lives. Otherwise, they lose that which makes them most valuable. With grants of money, there will inevitably be attempts (not malicious, but meddling) to get universities to do what the money granter thinks they should do, not what the university thinks it should do. All I can say is that the university must resist such pressures if it is to be true to itself. Some will, some won't.

4. What has been the experience of Notre Dame University with Federal project grants and contracts and other forms of support for research and education? Could you give us the figures on the amount of this support as a case example?

4. The material will be found in the committee file.

5. Since many Federal departments and agencies finance research and education among colleges and universities, do you think that the Foundation, in seeking new centers of excellence, should have authority and responsibility to coordinate grants and contracts for a specific institution, in order to obtain the greatest effect?

5. I am not sure that the National Science Foundation could or should coordinate all Federal grants. However, in studying the crea-

tion of centers of excellence, it should certainly take these grants into account—as an indication of excellence already existing and to avoid duplication or conflict of support.

6. To what extent have new Federal facilities at Notre Dame committed your future income in event of an early withdrawal of Federal operating support?

6. Not sufficient to ruin us if Federal support were withdrawn, but enough to cause us some very bad days and nights getting readjusted. Also, we would then be operating much less effectively than at present.

7. You spoke of the necessity for the National Science Board to delegate much of its early authority to the Director. In view of the rapid growth of the Foundation, would you not consider also that it is important for the Director to delegate much of his authority to other officials within the Foundation? To your knowledge, is this being done? Do you believe that Reorganization Plan No. 5 which gives the Director additional delegation of authority, will be beneficial in this way?

7. I believe the Director delegates to the extent possible and will do so even more the longer he is on the job. It takes more time than our new Director has had to see all of the potentialities in a rapidly moving field. I do not have Reorganization Plan No. 5 at hand, but would personally favor giving the Director additional power to delegate. May I add that there is much that he really cannot delegate—the overview of total National Science Foundation activity, priorities for the future, large and potentially troublesome decisions, contact with the Board and its main committees, budget planning and control, congressional and executive relationships, etc.

8. Do you believe that the retraining of science teachers is as effective as continuing their education immediately after graduation?

8. Effective in that teachers are at least already committed to education; students not yet. But I think we must do both to meet future demands.

9. Do you believe that NSF is overcontrolling its grantees by too many administrative requirements?

9. Controls tend to grow as the money involved and scope of programs grow. I personally favor broad institutional responsibility and a large measure of trust on the part of the Foundation, but it only takes one bad incident of irresponsibility to bring on pressure for additional control. The National Science Foundation certainly controls more now than it used to, but largely because of the above.

10. In an effort to spread its research grant money on a broad base does NSF, in fact, shortchange good projects by too limited support?

10. The only answer to this is a larger budget. One could, of course, tighten the scope, but then legitimate areas of science would be neglected. The National Science Foundation's really difficult problem is its mandate to support basic research in all areas of science and engineering, even where this involves large grants for national facilities in neglected areas. This inevitably squeezes the individual grant money in the total budget.

11. What long-term role do you see for the smaller colleges and universities in science and education? Has oncampus research become so important that those institutions which cannot afford it must sooner or later withdraw from education in the life and physical sciences?

11. I do not know the answer to this one—unless perhaps small colleges can establish research relationships with neighboring large universities and national research centers. The basic problem is that a good scientist who must do research to stay alive and grow will not go where this is impossible.

12. Should NSF increase its international scientific assistance to include support of research carried out by foreigners and/or Americans in foreign countries?

12. Under strict conditions: that the type of research is only possible abroad because of environmental conditions that are special—e.g. Antarctic; or the scientist (American) involved has to be kept alive scientifically while doing something abroad in the national interest. I could also see the National Science Foundation doing work overseas on contract support from agencies (like AID) that need the National Science Foundation's expertise for their special purposes.

13. With scientific talent in government concentrated in the executive branch, do you believe the scientific disciplines including mathematics and engineering should have more representation in our legislative bodies? Do you know of any effort by anyone to induce technically trained people to run for public office? Is this a proper educational objective?

13. Yes. No. Yes.

14. To what degree do graduate scientists and engineers drift away from their professions into other fields—such as management, trade or commerce, finance or other business. Is this good or bad? What can be done to improve career counseling?

14. To a rather large degree. It is both good and bad, depending on one's point of view. There is, of course, a movement in both directions. In societies like our own, freedom of movement is essential. Universities must stand for good values that will make career choices more meaningful.

15. At what grade level, in our modern educational structure, does a student chart his course toward science, engineering, social studies, business or the arts? Should the Foundation exert influence by the investment of support at this level?

15. The best that the National Science Foundation can do is to support good teaching at all levels, through teacher institutes, and the development of better teaching materials of all kinds. One would hope that other Federal agencies could promote similar progress in other legitimate fields of learning. Students should come alive to the excitement of learning in all fields and make their own choice of career according to their own talents and interests. This will happen for different students at different ages. In inadequate schools, it will never happen, to this Nation's loss.

Response by Dr. S. Dillon Ripley, Secretary, Smithsonian Institution, to Questions of the Subcommittee on Science, Research, and Development

1. As you know, in fiscal year 1965 fiscal and managerial responsibility for the Science Information Exchange were transferred to the National Science Foundation, which responsibility is exercised through a contract with the Smithsonian Institution.

(a) Was this transfer consistent with the current role of the Foundation as defined by the February 29, 1964, letter; namely, the coordination of non-Federal scientific and technical information activities and the development of Federal and non-Federal relationships?

(b) Does fiscal and managerial responsibility for the Science Information Exchange imply a measure of Federal coordinating responsibility?

(c) Was this transfer of responsibility regarded as "strengthening" the Exchange in accordance with the recommendations of the Presidential Scientific Advisory Council report?

(d) While NSF funds the operations of SIE, who has responsibility for professional supervision of its activities and maintaining the quality of its work?

1. The assignment of fiscal and managerial responsibility for the Science Information Exchange (SIE) to the National Science Foundation (NSF) was directed by Dr. Wiesner in his letter of June 6, 1963. The letter also provided that the operation of the SIE would continue under contractual arrangements with the Smithsonian Institution. Fiscal year 1965 was the first fiscal year for which NSF requested funding for the total SIE program.

(*a*) SIE collects and disseminates information about scientific research in progress over the broadest spectrum of scientific fields and handles research records from both Government and non-Government sources. On this basis, it would seem logical to assign fiscal and managerial responsibility for SIE to an agency with general responsibilities for, or a general interest in science. Thus it would be appropriate to assign responsibility to the National Science Foundation or to the Smithsonian Institution rather than to an agency that would be primarily mission oriented, concerned with limited scientific areas, and with far less responsibility for non-Federal relationships. It seems to the Smithsonian Institution that the assignment to NSF was consistent with the concepts expressed in Dr. Hornig's letter to Dr. Haworth dated February 29, 1694. We believe also that direct funding to the Smithsonian Institution would be just as consistent. NSF could still exercise—

> * * * leadership in affecting cooperation and coordination among non-Federal scientific and technical information services * * * and in developing adequate relationships between Federal and non-Federal scientific activities.

(*b*) This question is not clear as to "coordinating responsibility" for what. According to the SIE Charter, its mission is to collect, organize, and provide information on current research in order "to facilitate more effective planning, management, and coordination of the scientific research and development activities sponsored or supported by U.S. Government agencies." While the final responsibility for program coordination remains with the agencies themselves, it seems clear that SIE is responsible for collecting, organizing, and providing information that will assist and facilitate this process. The adequacy of support of SIE by the NSF will condition, in no small measure, the effectiveness of this service.

The Wiesner letter of June 6, 1963 provides for operation of the SIE by the Smithsonian Institution and funding by the NSF. It also provides for an Advisory Board to the National Science Foundation on SIE matters, with memberships from agencies with major research grant programs as well as the Smithsonian Institution. This is a coordinating mechanism. The Wiesner letter also stated:

> Accordingly, the National Science Foundation, with the advice of the Advisory Board, is charged with revising the present charter and providing the Committee on Scientific Information with recommendations for vigorous administrative action to insure proper technical inputs and support of the Science Information Exchange effort by all Federal agencies in the physical sciences.

(*c*) We assume reference is made to the "Report of the President's Science Advisory Committee of January 10, 1963," often referred to as the Weinberg report. The transfer to NSF provided for line item funding as recommended by the report. This could have been done by appropriation directly to the Smithsonian (which was seriously considered) or through NSF. The current responsibility for a strengthened program rests with the Office of Science and Technology, the National Science Foundation, the Smithsonian Institution, and the Science Information Exchange and the agencies represented on the Federal Council for Science and Technology and on the Science Information Exchange Advisory Board.

(*d*) Overall responsibility for SIE resides in the Office of Science Information Services, National Science Foundation, for the establishment of policy and scope in consultation with the Smithsonian Institution and the Advisory Board.

The Smithsonian Institution has full responsibility for operating the SIE, including professional supervision of its activities. The maintenance of a quality product is dependent to a large extent on the "diligence and care" of the various Government and private agencies cooperating with the Exchange in "collecting current efforts intelligence, and in forwarding it, suitably packaged, to the Exchange."

2. How complete, percentagewise, do you consider the substantive material comprising the Science Information Exchange to be? Can you give an estimate on this, in regard to both Government and non-Government inputs? In other words, how much of the U.S. technical information is the Exchange getting and how much is it missing?

2. We believe that about 90–95 percent of all unclassified basic and

applied research tasks supported or carried out (in-house) by the Federal agencies in life and social sciences is now being registered in SIE.

Since there is no sound estimate of the total number of Federal tasks extant, and since SIE has collected physical sciences records for only 2 or 3 years, we do not have firm basis in fact or experience for reliable estimates in this field. However, we believe that approximately 50 percent or less of the basic and applied Federal research tasks in physical and engineering sciences are now being registered. Registration of the major outstanding programs in NASA are anticipated in the next few months. DOD has promised only unclassified basic research; DOD is studying the question of unclassified applied research.

In regard to the non-Government input, we have no way of estimating the non-Federal national effort in terms of number of tasks. If it may be assumed that 60–70 percent of total R. & D. dollars are from Federal sources, the non-Government dollar level may be about half the Federal effort.

SIE has intensified its effort to increase the collection of non-Government research records, now that comprehensive Federal coverage is nearing completion. Efforts have been directed toward the major sources of information, i.e., the non-Government agencies that support or carry out substantial and significant research programs. Lacking a factual basis for estimating the total number of tasks extant, an estimate of percent coverage would be most unreliable. Our best appraisal of progress is, therefore, noted in general terms as follows:

(*a*) In fiscal year 1965, 125 private foundations and fund-raising agencies, such as American Heart Association, American Cancer Society, Hartford Foundation, and others, with research programs at the national level registered their research at SIE. More comprehensive coverage of programs from these sources is being pursued as fast as SIE resources and manpower will permit. One rough estimate suggests there may be as many as 5,000 or more private foundations and trust funds for research support in the United States. Many of these are probably quite small. From other sources, we have estimated that probably 200 to 300 of the largest may well represent the major contribution of this kind.

(*b*) State and city governments support research programs in such fields as public health and mental health, wildlife and conservation, agriculture, geology, oceanography, commercial fisheries, highway and building research, water resources research, sociology, regional and urban planning.

All the States do not support all these areas of research, and we have had insufficient experience to date to offer a reasonable estimate of the total number extant. In fiscal year 1965, 89 State agenices from nearly all 50 States registered some part of their research programs, and a total of over 5,000 registrations were received from these sources. Here again, collection is proceeding as fast as SIE can identify the programs, solicit and arrange for their registration.

(*c*) Many universities carry out substantial research programs supported by their own funds, local gifts, grants and contracts, besides the research supported by Federal and foundation funds. About 40–50 universities have been contacted to date and in every case have expressed their interest and willingness to participate. In fiscal year 1965, 36 universities registered some of their non-Federal research. This source has developed slowly, however, since projects are usually scattered throughout many different university departments and scientific disciplines. In a large university, identification and collection of the dispersed records is somewhat slow. We have noted, however, that universities are showing an increased interest in a central inventory for their own internal research management. Occasionally, SIE has been able to assist by providing computer lists of their projects already registered at SIE. When universities have developed their own inventory control points, collection and exchange arrangements with SIE can proceed more rapidly and efficiently.

(*d*) For some years, industry has offered token cooperation with SIE in regard to academic research grants that have no patent implications. Competitive secrecy, however, has not encouraged the registration of industrial in-house research. Several corporations have recognized, in principle, the mutual advantages of limited registration, and have suggested the feasibility of furnishing information on such projects as new analytical methods, and others where patent possibilities are remote. SIE has not vigorously exploited these sources since it may be some time before industry will contribute more than token registration.

Contact is maintained with industrial research groups for possible future participation, but greater effort is currently directed to other sources that promise more immediate response. Although in fiscal year 1965, 31 companies registered some research with SIE, the total number of such projects is small.

3. Can you supply for the record, on an agency-by-agency basis, the kind and amount of data the Exchange receives from Government sources; and also some measure of the extent to which these agencies make use of the Exchange?

3. Input and output by agency (see table).

Input and output by agency

	Input (fiscal year)		Output (fiscal year 1965)				
	1964	1965 [1]	Special projects	Administrative requests	Subject questions	Investigator reports	Automatic distribution
Federal:							
Agriculture	9,563	9,808	1	6	108	13	
AEC	2,567	1,392		5	20	992	8,729
Commerce	1,001	2,489	1	1	26	101	1,296
Congressional				6	43	127	
DOD	9				5	1	
Army	1,835	185		2	196	8	530
Navy	2,227	1,665		2	100	34	278
Air Force	3,161	1,430	1	1	171	221	
FAA	501	9			9		933
HEW	20,827	18,988	4	113	437	28,003	257,994
Interior	3,022	3,630	3	4	199	11	107,807
Labor	94	69			6		398
NASA	782	418			24	145	238
NSF	4,662	4,127	3	2	98	3,437	2,651
SI	1	297		4	16		
State	30	23		9	13		38
VA	6,580	6,199	1	20	146	6	43,505
HHFA	1						
TVA	125	105					
Other Federal			2	6	114	1	
Subtotal	56,988	50,834	16	181	1,731	33,100	424,397
Non-Federal	10,530	11,280		94	3,656	2,399	5,687
Grand total	67,518	62,114	16	275	5,387	35,499	430,084

[1] Grants are recorded by the Science Information Exchange for the fiscal year in which the grant is awarded. The grants listed herein for fiscal year 1965 represent only those that have reached or cleared SIE as of this date. All records for a fiscal year do not reach SIE until several months after July 1.

GENERAL NOTES AND DEFINITIONS OF TYPES OF OUTPUT

NOTE.—The kind of data received from Government sources is shown on the attached sample of the notice of research project (NRP). This is the input of the Exchange. About 75 percent of the Federal registration is furnished on NRP's. The remaining 25 percent comes to SIE in various stages of completeness and format.

NOTE.—About 25,000 NRP's describing pending research proposals, i.e., applications for grants, are received annually from several agencies. When notified of action by cognizant agencies, rejected proposals are destroyed; accepted proposals are then registered as active projects. These records are not included in the input statistics reported in the attached table.

Definitions

Special projects.—Specially indexed compilations for publication or specialized distribution involving broad interdisciplinary areas and requiring extensive committment of SIE resources. (Example: Production of the water resources research catalogs for publication by the Department of the Interior. (All of this category are for Federal offices.))

Administrative requests.—Requests for information involving no subject dimension, compiled according to source of support, location of research, or accession number. (Example: Tabulation of all federally supported research to the State of California by performing institution. (89 percent of this category are for Federal offices.))

Subject questions.—Requests for information that specifically involve subject matter dimensions. (Example: All current research on the kinetics of conversion of anhydrous boron oxide to boron nitride. (80 percent of this category are for Federal offices or Federal contractors and grantees.) Note: The table shows a volume of subject questions services for non-Federal offices. Samples indicate that at least 43–50 percent of these offices are performing federally supported research in the general subject area.)

Investigator reports.—Requests for information concerning research being performed by a specific investigator or investigators. (Example: All research being performed by David T. Roberts. (99 percent of this category are for Federal offices.))

Automatic distribution.—These are numbers of extra copies of NRP's requested by agencies for their own files and internal records.

NOTICE OF RESEARCH PROJECT
SCIENCE INFORMATION EXCHANGE
SMITHSONIAN INSTITUTION

NOT FOR PUBLICATION OR PUBLICATION REFERENCE .

PROJECT NO. (Do not use this space)
GP 77
AT(30-1)-2672

SUPPORTING AGENCY: Division of Research
United States Atomic Energy Commission

TITLE OF PROJECT: Mechanism and Rate Study of Butadiene Produced Using C^{14} Labeled Intermediate Compounds.

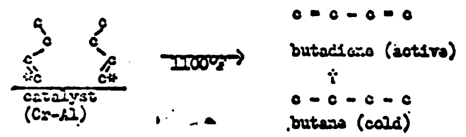
Give names, departments, and official titles of PRINCIPAL INVESTIGATORS and ALL OTHER PROFESSIONAL PERSONNEL engaged on the project.

Department of Chemical Engineering:
John Happel, Professor of Chemical Engineering
Y. Okamoto, Research Scientist
D. Desouza, Research Assistant

NAME AND ADDRESS OF INSTITUTION: New York University
University Heights
New York 53, N.Y.

SUMMARY OF PROPOSED WORK -- (Approximately 200 words. Omit confidential data.) In the Science Information Exchange summaries of work in progress are exchanged with government and private agencies supporting research, and are forwarded to investigators who request such information. Your summary is to be used for these purposes. Please make your summary substantive in nature, rather than generally descriptive.

In the dehydrogenation of butene-1 tagged with radioactive beta-emitting C^{14} in the 1- position, it was found (1) that cold butane and radioactive butadiene were produced:



If this observation is correct, it would rule out the class of single site mechanism and favor dual site mechanism, that required adjacent activated molecules.

It is the purpose of this proposal to establish this most unexpected observation using the radioactive butene tagged with C^{14} in the 1 or 2 position as the starting material, and further, to determine the position of the radioactive C^{14} atom in the butadiene produced.

(1) This result was obtained at New York University under AEC Contract AT(30-1)2672.

SIGNATURE OF PRINCIPAL INVESTIGATOR John Happel John H. Happel

Submitted for period beginning January 1963

Identify the Professional School (medical, dental, public health, graduate, or other) with which this project should be identified:
SCHOOL New York University

INVESTIGATOR — DO NOT USE THIS SPACE

GP 77	Period of Operation 1/63 - 12/63	Amount Appr. $9,821

4. Last year the Select Committee on Government Research found the future effectiveness of the exchange was endangered by the proliferation of interagency and intra-agency information clearing centers. Has this situation changed during the past year?

4. SIE has always been of the opinion that intra-agency clearing centers should be and eventually would be organized and specialized to serve internal agency management needs. Cooperative exchange arrangements with SIE could then channel all agency information to SIE that would be appropriate for interagency needs. SIE would then direct its major efforts to interagency exchange. Such arrangements should avoid any serious duplication, overlap, or conflict since

information for internal agency management is handled differently and in much more detail than the same basic stock of information would be handled, organized, detailed, and used for the broader aspects of interagency information exchange. A case in point is the successful collection and organization by SIE of a broad spectrum of basic and applied research related to water resources. This embraces scattered interdisciplinary aspects, includes selected segments of a number of applied research fields, and is extracted from the research programs of more than five Federal agencies. In addition, significant programs are contributed by 30 different State research agencies.

In our opinion, considerable progress can be made in such cooperative exchange arrangements with intra-agency systems.

Interagency exchange systems do not yield quite as clear-cut division of mission and purpose. In cases where a limited scientific discipline or applied field is concerned, a reasonable modus operandi for coordination and cooperation can be worked out. For example, negotiations are now underway with a highway research information center for full exchange of pertinent data, as well as coordination and cooperation in the collection of research records. The highway research information center, however, specifically serves the detailed needs of its user-community, while SIE can select those segments of highway research in the earth science and construction materials that are needed by SIE for information services in water resources research. By the same token, selected aspects, such as research on traffic patterns, by suitable modifications, can be adapted to SIE's organization of research information for urban renewal research.

Other interagency clearing centers that have recently appeared present the possibility of some overlap with SIE. Where the main emphasis is on report literature and the documented research results that are not handled by SIE, there would be only minor areas of overlap. Working agreements for coordination and exchange cooperation have been recently developed with the Department of Commerce Clearinghouse and the National Referral Center. These arrangements are intended to identify and eliminate any duplication in areas that seem likely to overlap. Research programs from the Bureau of Reclamation, Department of Interior, and the Office of Antarctic Program, National Science Foundation, are now being registered. Basic and applied NASA programs are to be registered in the next month and delivery of the basic science part of DOD research is expected about October or November.

5. Supplementing your testimony, are the organizational relations of the Exchange and the Foundation with other departments and agencies adequate to obtain information on in-house research projects as Government laboratories as well as the work they sponsor through grants and contracts?

5. Much of the in-house work of the Federal agencies has been registered at SIE during the past several years. Members of the Advisory Board representing each agency have traditionally been SIE's point of contact at each agency to assist and facilitate the input of all research projects, inhouse, as well as extramural grant and contract programs. The major factor for getting this input has been the interest and willingness of the agencies to fully support SIE's program

and get the job done, and on the position and influence of the Advisory Board representatives within their own agencies. Dr. Wiesner in his letter of June 6, 1963, requested the agencies to designate a high-level official for the Advisory Board representative, preferably from a research arm of the agency. This helps achieve appropriate organizational relationships to obtain in-house research.

6. What has been done administratively since the issuance of the Elliott report on R. & D. information to improve the efficiency of correlating and disseminating scientific information?

6. A number of internal administrative steps were initiated by SIE to increase its efficiency and effectiveness before and since the issuance of the Elliott report. SIE had a management survey in the summer of 1964 which resulted in a number of internal management improvements. At present, a survey of user requirements is underway by an outside firm.

However, we believe this question refers to administrative actions taken by OST, the FCST, and NSF concerning the Government-wide aspects of the correlation and dissemination of scientific information. SIE has information only on current efforts work. The complete agency inputs have not come through on current research in the physical sciences in DOD and NASA as yet; information has been disseminated in new formats to meet new needs as discussed in the comment on question 7.

7. Are the actual dynamics of the communication process relatively stable, or forever changing? Are enough funds available for carrying out experiments to apply new knowledge, techniques, and equipment for more efficient information retrieval systems?

7. There are two aspects to the dynamics of the communication process. From the viewpoint of present information retrieval systems, there are, indeed, rapid changes in computer developments and their applications to information retrieval. There is also rapid progress in theoretical systems design and concomitant application to practical operations. On the other hand, there appears to be a significant and rapid change in the nature and sophistication of user demands and user requirements, for which new approaches to systems design may be needed. This is more on the side of the advanced intellectual aspects of information needs rather than operational mechanics noted above.

A case in point is the new and growing demand in the past year at SIE for the extensive organization and cataloging of broad multidisciplinary collections of all research related to such varied fields as water resources, urban renewal, oceanography, pesticides, building research, and others.

SIE has had normally about five experimental studies more or less continually underway to explore and develop the means and methodology to meet these changing requirements, as well as the ever-present problems of increasing its operating efficiency and economy. However, SIE has been funded in recent years primarily as a service function.

8. Do you believe that NSF's grants are made for too short a period? Are they spread too thin in order to accommodate a larger quantity of proposals? Is NSF now requiring too much by way of administrative regulation to permit the best work on its grants?

8. NSF grants are usually made for the period of time requested by the applicant, and for not more than 3 years. However, the applicant is advised whether or not he can seek renewal with additional funds at the termination of the period, and he is often encouraged to seek extensions of time without additional funds. Although the amounts of money requested by applicants are often reduced in the final grant, this is done on the advice of outside consultants and is not intended to "spread the money thin." The grants are adequate in most cases. Considering the volume of money involved and the necessity to seek advice widely, the administrative regulations involved are minimal, and complaints from the scientists about them are seldom heard.

9. The point has been brought out during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say by agency X, agency Y, or both. More specifically:

(*a*) *What guidelines or criteria have been established by the Smithsonian Institution to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the agency's jurisdiction and, therefore, should or should not, be supported by the Smithsonian?*

(*b*) *If written criteria have been established by your office, please submit a copy thereof to the committee.*

9. The Smithsonian Institution has very little money for the support of outside research. On the rare occasions when the Smithsonian has supported research by outsiders, it has often been because of close tie-ins with staff interest.

Criteria for support of research by any agency can be most easily related to the mission of the agency. The qualified administrator of grant or contract funds must first decide whether the proposed research promises to contribute most directly to the mission of his own or another agency. On this basis research related to disease problems may be referred to NIH or that providing information with direct application to disposal of nuclear wastes may be referred to the Atomic Energy Commission.

Where a research proposal seems to make no special contribution to any other agency it would seem to fall within the purview of the NSF. The Smithsonian Institution, although having a broad charter, generally would select projects promising to give information in support of its research bureaus.

In some cases, the staff of the Institution may elect to support a project of doubtful acceptance by another agency because of special Smithsonian interest.

No written criteria on this matter exist within the Smithsonian Institution.

10. In your annual report, you noted that to overcome shortages of competent investigators, the Institution has begun studies of expanding educational opportunities in neglected areas of the natural sciences. What contacts have you had with the Foundation about such training, and with what results?

10. The Institution receives reports and participates in studies sponsored by NSF to describe the manpower situation in science. The shortages of systematists in biology as well as other types of scientists have been revealed by NSF studies.

NSF support of scholarships and fellowships particularly at the graduate level is restricted to academic institutions. We have been informed by NSF that we are not eligible to participate in their fellowship program as a project agency. On the basis of our discussions with NSF we are considering the establishment of a fellowship program to meet our special manpower requirements.

11. The Smithsonian provides some support for training in broad areas of biology and anthropology not otherwise available under existing university programs:

(*a*) *Has the Institution been able to obtain assistance for this from the Foundation or the Office of Education?*

(*b*) *Does the Institution believe such training should be the role of the Foundation?*

11. The Smithsonian conducts basic research in the sciences. In biology and anthropology, Smithsonian research is either not at all pursued in university research centers or is given inadequate attention there. Because we believe that biology and anthropology are vital areas of research, and that scientists and scholars should be given the opportunity of learning more about them and pursuing their own research objectives in them, the facilities of the Institution are made available to advanced research scientists, and to graduate students who plan to enter these fields of study. Toward this end, the Smithsonian has been developing plans for a postdoctoral visiting research associate program and a predoctoral internship program.

(*a*) Although the Foundation has given the Institution an $11,000 grant for undergraduate education for the summer, 1965, however, the Institution has not obtained direct assistance for these above programs from the Foundation or from the Office of Education. However, scholars granted fellowship funds through an academic institution by the Foundation or by NDEA programs in the Office of Education may use them for salary support while being trained at the Smithsonian. In such cases, the Smithsonian generally has to support from its own funds, facilities, equipment, and supplies for such scholars.

(*b*) Since the NSF grants fellowships only through general competition (not by specific fields) it has become necessary for many agencies to establish their own fellowship programs to meet urgent needs in a special field (i.e., AEC, PHS). Since certain areas of scientific research at the Smithsonian are particularly in need of support, we are (as mentioned above) considering establishing a special fellowship program.

12. What is the nature of the Institution's cooperation with universities mentioned in your annual report? What has been learned from this experience that is pertinent to future activities of the Foundation?

12. The Institution's cooperation with universities is responsive to longstanding legislation that the Institution shall be responsible to see that the national collections are studied. Encouragement of aca-

demic involvement in the Institution's programs increases the availability of scientific manpower and brings new concepts and new interest to our programs.

Each cooperative arrangement is designed to meet a particular problem in a research field, both for the university and for the Institution. It may involve members of Smithsonian departments taking leave from their posts to teach or do research full time for a semester on the campus. In other cases, students initiate or continue thesis research under the direction of an Institution staff member. Complete courses—lectures and seminar meetings—may be held in Smithsonian facilities with Smithsonian staff members serving concurrently as off campus staff members of the university.

Some of the programs allow students to work closely with full-time research scientists on unique collections. In the arts and humanities similar programs enable students oriented primarily toward books to become involved with the actual sculpture, the actual musical instruments, that make up the discipline in which they are studying.

The Foundation has long encouraged cooperative arrangements between and among universities. They have encouraged our entering such agreements and contributed to the universities part of the cooperation. Thus our experience verifies the validity of the NSF program.

13. Has the Institution in its Department of Science and Technology investigated the relationship between basic and applied research and development on one hand and the national economy, and perhaps regional economies, on the other? How should such responsibilities be divided between the Smithsonian and NSF?

13. The Smithsonian Institution has not investigated the relationship between basic and applied research and development and the national or regional economies.

The Department of Science and Technology of the Museum of History and Technology performs research in the history of technology and the physical sciences primarily related to the development of the sciences and scientific instrumentation and to the evolution of engineering, machines, tools, and processes. These studies include occasional reference to the cultural effects of scientific and technological development but they contain very little with regard to the relationship between these developments and the national and regional economies.

The staff envisions the possibility of the addition of an economic studies unit to extend the usefulness of its present programs. However, no plans have been made for this activity and the Smithsonian has not studied the matter in sufficient depth to answer the question of how the responsibility should be divided among various agencies.

14. Your report mentions an effort to contribute to the efficiency of research through studies of ways to promote the application of data processing, technician employment and training, improved cataloging methods, and more rapid indexing and retrieving of information in the biological sciences.

(a) How do these relate to the Foundation's responsibilities for training and education and for scientific information?

(b) Is the study of technician training likely to indicate a need for greater effort to provide qualified technicians and perhaps a role for the Foundation in such training?

14. (*a*) We share the concern of most agencies with the use of data processing techniques for the increase of output and efficiency. We have sponsored several studies of the applications of storage and rapid recall of data to museum operations. We are constantly on the lookout for ways to improve our cataloging and indexing systems in order to provide more rapid access to the collections and study materials.

Recently, we have broadly advertised our plans to develop a coding system for biological names which will enable us to locate and compare data in our collections from several directions. The NSF is strongly interested in this program since it has supported projects with related aims. NSF encouragement and consultation in the effort has been a factor in determining the method of approach and the continuing work. Their advice is sought and the results of the work are considered jointly with them for application elsewhere in the museum and to other scientific areas.

(*b*) The employment of technicians in the museum has been carried out within general Civil Service regulations. The new technician has generally required extensive and continuing on-the-job training before becoming proficient in this type of employment. Although no courses presently exist, the Institution is seriously considering the establishment of training courses. The increased use of more technicians should increase the efficiency and output of scientists on our staff.

Generally it has not been a practice of the NSF to support technician training, such support going to the education of scientists. If our museums along with others use more technicians in the future, we will consider with NSF who should develop curriculums and support courses for technician training. In the meantime, we will continue to experiment with various on-the-job training techniques for our new technicians, making the results available to NSF. In the past, NSF has provided funding support where special training concepts are involved.

15. What is the level of effort of the Smithsonian's study of science and technology and how does this compare with the Foundation's support of research in the history and philosophy of science?

15. The Department of Science and Technology has a staff of 13 historians. This staff performs research studies comparable on a man-to-man basis with those performed in a university department. The Smithsonian staff is engaged in other curatorial duties including documentation of collections, the planning of educational exhibits, the preservation of collections, and furnishing information in response to inquiries received from historians, students, and the public. Approximately one-third of the staff's time is devoted to the study of the history of science and technology. The staff of the department is larger than that of any university department of history of science and technology.

The cost of the Smithsonian Institution effort calculated on the basis of one-third of the time of the historians involved was, in 1965, approximately $135,000 for salaries and supporting services.

In response to the inquiry made, the Office of Social Sciences of the NSF reported that it supported in 1965, 36 research projects in the history and philosophy of science in the amount of $891,000.

16. To what extent did the early fostering of land-grant colleges contribute to the development of American industrial technology?

What lessons do you see in this experience that should be kept in mind by the Foundation in carrying out its programs of institutional support?

16. The NSF program of institutional support is designed to provide that funds will be available for imaginative research by creative scientists and scholars, who because of lack of experience, narrow background of acquaintance, and/or recent graduation from a university are not likely to receive a research award from the Foundation.

The land-grant colleges utilize fertilizers from chemical industries and equipment and tools from mechanical industries. They encourage new processing industries for agricultural products. They have contributed to the growth of transportation related industries.

Thus, the land-grant colleges have broadened the base of support for agricultural sciences and it is anticipated that NSF institutional support will broaden the capabilities and competencies of today's universities. As concentration on agriculture resulted in industrial developments and as the emphasis on space has resulted in the production of sophisticated vehicles for entry of that environment, it is expected that industry will contribute to the solution of various types of equipment and other problems raised by the NSF's institutional support.

RESPONSE BY DR. ERIC A. WALKER, CHAIRMAN, NATIONAL SCIENCE BOARD, AND PRESIDENT, PENNSYLVANIA STATE UNIVERSITY, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

1. The National Science Board was characterized by Dr. Waterman in his testimony as "a unique body for dealing with policy matters." and he advocated more use of it within the executive branch by such agencies as the Office of Science and Technology, the Federal Council for Science and Technology, and the President's Science Advisory Committee. What is your comment?

1. Obviously this was a great opportunity for the National Science Foundation, but one it did not seize.

Although there have been a few reports providing guidance for all levels of the Federal Government, these have been few and far between. A notable exception was the report authored by Dr. Bolt when he was assistant director of the Foundation entitled "Investing in Scientific Progress." But, unfortunately, the National Science Foundation, to outsiders, seemed to lack the will to do much in this direction, although it was admirably equipped at the top levels with a board and divisional committees to do so. Nevertheless, the proper supporting staff was not easily available and the reports were not produced.

Eventually, Government agencies turned elsewhere for background and policy reports; to A. D. Little Co., to the National Academy of Sciences, and so on. Reports such as "Ground-based Astronomy—A 10-Year Program" (the Whitford report) and "Economic Benefits From Oceanographic Research" (a National Academy of Sciences-National Research Council publication) are examples. By now few people expect the Board of the National Science Foundation to provide such studies or such guidance.

Recent attempts to provide guidance under the new Board structure are:

(*a*) "The Role of the National Science Foundation in Support of Research in Ground-Based Astronomy" proposed by Committee III and approved by the Board at its 100th meeting (May 1965). (NSB/C-III-65-13.)

(*b*) "Use of Digital Computers in Universities and Colleges" proposed by Committee I and adopted by the Board at its 100th meeting (May 1965).

More of this latter kind of guidance is needed, but to produce them is a heavy burden on the Board which it cannot carry without additional help.

2. As you know, Reorganization Plan No. 5 would abolish the statutory divisional committees. In his appearance before the Executive and Legislative Reorganization Subcommittee, Dr. Haworth stated that the number of divisional committees has proved cumbersome; and

he cited as an example that under the NSF Act three committees were now required to deal with scientific personnel and education matters, whereas one committee was all that was necessary.

(*a*) *Rather than abolish all eight divisional committees, why didn't the NSF just reorganize the three committees concerned with scientific personnel and education?*

(*b*) *Have the divisional committees really fulfilled their original purpose?*

2. The history of the divisional committees is an interesting one. The original National Science Foundation Act (Public Law 507 (1950)) required a committee for each division of the Foundation, and went on to specify the terms of office and said that such committees "shall make recommendations to and advise and consult with the Board and Director with respect to matters relating to the program in its division." A Board directive dated 1960 spelled out in more detail the duties of the divisional committees assigning them a number of important duties through which they were to assist the Board and Director in their operations. At least once each year the divisional committee chairman was to be invited to a meeting of the Board in order to report on, and discuss the activities of his divisional committee. Moreover, at one time the Board suggested that annual meetings be held of all the committee chairmen to discuss topics of common concern to all committees, or programs which were of concern to all committees. Five such meetings were held.

There have been occasions when joint meetings have been held between full committees of the Board and the divisional committees. The last such meetings were those of the Biological and Medical Sciences Board Committee in 1963, and the Scientific Personnel and Educational Board Committee which met with its corresponding divisional committee in the same year.

The present practice is to have a member of the Board attend each meeting of the divisional committee. A staff member reports to the Board on the deliberations of the divisional committee and the Board member usually offers further information and comments.

Thus it is quite evident that the committees are an invaluable arm of the Board.

However, the Board of the Foundation did not vote on the abolition of the statutory requirement for divisional committees. The reason behind this are quite clear cut.

In the Reorganization Act of 1960 [1] the divisional committees reporting channel was shifted from the Board and the Director to the Director alone.

At the September 1964 meeting the Director informed the Board that he "was considering the possibility of requesting, through the Reorganization Act procedure, an amendment to the National Science Foundation Act which would relax the rigid requirements relating to divisional committees by repealing section 8." At the May 1965 meeting the Director reported that the President had submitted Reorganization Plan No. 2 which included such provisions to the Congress on May 13, 1965. Reorganization Plan No. 5 of 1965 which abolished the requirement for the divisional committees became effective on July 27, 1965.

[1] The Reorganization Plan No. 2 of Mar. 29, 1962, establishing the Office of Science and Technology, provision No. 4 of which was "the divisional committees will report to the Director rather than to the Board and the Director."

I do not think the Board expects that the divisional committees will be abolished. If they are, an important link with the scientific community will be severed.

3. The point was brought during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. Specifically:

(a) What guidelines or criteria has the Board established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of NSF's jurisdiction and, therefore, should, or should not, be supported by the Foundation?

(b) If written criteria have been established, please submit a copy thereof to the committee.

3. From time to time the Board has set forth guidelines as to the extent of the Foundation's support to be granted in certain areas. For example, the Board at its 77th meeting (May 1962) approved a list setting forth the types of engineering projects which the Foundation would be prepared to support under its expanded program (see NSB–491, app. VII) which follows:

APPENDIX VII

POLICY RELATING TO THE SUPPORT OF PROJECTS IN THE ENGINEERING SCIENCES

The announcement some months ago of the establishment of an Engineering Section within the Foundation to supersede and absorb the engineering sciences program has resulted in a number of inquiries concerning the essential significance of this move. The news release that was issued at the time of the establishment of the section generally described the revised scope of the program. In view of the interest generated, we should be prepared to support meritorious reresearch projects along such lines as:

(*a*) The development of principles and techniques in systems engineering design.

(*b*) The development of principles and a philosophy for creative engineering.

(*c*) Interdisciplinary research related to such matters as biomedical engineering, transportation, urban planning, fire prevention, etc.

(*d*) The principles of generation and control of energy systems and information systems.

(*e*) Analysis and synthesis of processes and systems which contribute to mastery of the environment.

It is recommended, therefore, that the Board adopt the following resolution:

"*Resolved*, That the National Science Board considers that intellectual pursuits at educational institutions intended to advance significantly the basic engineering capabilities of the country are eligible for support by the National Science Foundation as basic research in the engineering sciences. Such work must be of a true scientific nature and not routine engineering practice, and must meet the usual NSF standards of originality and excellence."

ALAN T. WATERMAN, *Director*.

4. What science policy function does the Board now serve that is not adequately provided for by existing organizational arrangements within the Executive Office of the President?

4. This is a very difficult question to answer because it assumes that science policies being developed within the Executive Office of the President are generally known. This is not so.

There is no doubt that all science policy functions could be centralized in one office or department. However, if they were, we would have in fact, if not in name, a Department of Science, with all policy and all control of funds for science channeling through one source. There are many scientists who feel that there is strength in having a diversity of sources of funding, and a diversity of policies in dealing with scientific problems and the academic community.

5. In your judgment, should NSF be given greater operational authority? Why, or why not?

5. I believe that the National Science Foundation should be given greater authority. This, however, would require a permanent and specially selected staff. The analogy for this course of action is the Naval Research Laboratory, which is funded through the Office of Naval Research. The Laboratory, which has an excellent reputation, can often provide a technical assistance to the Office of Naval Research and it always provides a standard against which some contract or grant research can be measured. The National Science Foundation does not have such an operations staff of Government employees in any field, but such a capability in oceonography would have been extremely helpful in establishing the Mohole project.

If the National Science Foundation gets into the support of large engineering research projects, such as weather modification, water retrieval, transportation, and the like, it will find it difficult to write such large contracts with industry or with universities. National laboratories operated by the Foundation would be one answer.

6. Do you consider the social sciences as positively within the purview of the Foundation? How does the Board define NSF's role for support of research in the social sciences? Is this role likely to increase or decrease?

6. I personally consider the social sciences as certainly coming within the purview of the Foundation, but at times it seems the Foundation has been a little timid in accepting this responsibility.

On December 1, 1958, and January 23, 1959, the Board approved a report which contained the following:

> Accordingly the National Science Board considers it proper and desirable for the National Science Foundation to support basic research in the social sciences where such research meets the usual scientific criteria of objectivity, verifiability. and generality.

Strangely enough, however, the Committee which wrote the report went on to say that, "to direct and guide this growth the Committee would recommend the establishment of an office (not a division) of the social sciences." The Board was reluctant to go all the way and recommended Divisional Committee, although the Board said that there should be an advisory committee similar in caliber to the present Divisional Committees. The reason for this strange reservation is not clear to me.

Nevertheless, the growth in support of the social sciences has risen rather spectacularly from $300,000 in 1957 to $9 million in 1965, and the growth should and will continue.

Undoubtedly, with the passage of acts establishing a National Arts Foundation and a National Humanities Foundation the position of the social sciences in the National Science Foundation will become more

easily defensible since they will not be covered by any other organization (e.g., a National Social Science Foundation).

7. The budget of NSF has increased from about $15 to $480 million, and some witnesses have suggested that it become as large as $1 billion in the foreseeable future. With this tremendous growth, is it in the best interest of science to maintain this dual (Board and Director authority over NSF, or would it perhaps be better to have the Director solely responsible for the management and operation of the Foundation, and have the Board serve in an advisory capacity to the Director (a National Science Advisory Board)?

7. Stated more bluntly, but perhaps more incisively, this question could be "who is going to run the program of the National Science Foundation? The Board of the National Science Foundation, or the Office of Science and Technology (the President's Scientific Advisory Committee)?" This has been a problem which has been debated in one form or the other at great length by the Board. Perhaps it would be wise to outline the history of events up to the reasking of this question.

It should be realized that the Congress, by establishing the National Science Foundation, created a new method for Government operations. The original suggestions for the act came from officers of foundations and universities, and every attempt was made to provide a foundation which would follow the same kind of operation, with a board of trustees, a president, and an operating staff. This is quite different from the normal Government operating agencies which must report to the administration and to the Congress. When finally established, the National Science Foundation was different from other agencies in that there is in fact a third source of policy guidance and control, the National Science Foundation Board.

It will be recalled that in the first version of the act the Director was to be appointed by the Board (customary university practice). To this, President Truman objected by saying that the Director must be appointed by the President and be responsible to him, and not to the Board. [This problem is discussed more completely in a Board report "Report of the Ad Hoc Committee on the Relationship Between the Board and the Director" of December 1, 1958—The Middlebush Report.]

Eventually, the act was passed providing that the Director should be appointed by the President, with the approval of the Senate.

This act then created a strange arrangement in which the staff of the Foundation reported to the Director, the Director reported to the President, but the Board was responsible for policy and programs without having its own staff. There were thus three groups which had some measure of veto power over the activities of the Foundation; the Board, the executive branch, and the Congress. As long as all three groups are in favor of a given policy or project, there is no problem. So far, there has never been a confrontation in which one of the three felt it necessary to use the power of veto. However, the opportunity for conflict has always been there.

The Board spent a great deal of time in 1961 and 1962 discussing how well this relationship had worked. Dr. Baker, as chairman of an ad hoc Committee on the Organization of Government for Science and Technology, produced a report on the matter which said in essence that continued successful operation was possible.

On March 15, 1962, the Board was informed that a reorganization plan was being written for submission to the Congress "which will among other things create an Office of Science and Technology in the Executive Office of the President. This act was expected to do several things. It would transfer the evaluation function (of the Board) to the new Office and the authority to develop and encourage a national policy for basic research and education in the sciences. Other changes would make the Director a voting member of the Board, and have the divisional committees report to the Director rather than jointly to the Director and the Board." [1] There were other proposals which were intended to reduce the size of the Board and to change the term of the Director. All of these proposals were discussed. Some of which met with approval and others with strong disapproval.

This matter was discussed in executive session on March 15, 1962, and it was agreed that it would be unfortunate to reduce the size of the Board, change the term of office, or to reduce the Board to an advisory board only.

At one point in the review the Chairman, Dr. Bronk, summed things up by saying:

> I consider the relationship between the Director and the Board to have been most satisfactory—there have been no unresolved matters between them. By being responsible for the formulation of policy and decisions on the Foundations programs and budgets, the Board members have felt that they have rendered a considerable service to science in this country. *These same members would probably not have given so freely of their time and effort if they had been serving only in an advisory capacity.* [Italic supplied.]

As a matter of fact, Dr. Bronk felt the organization of the Foundation might well serve as a pattern for other Government agencies.

To complete the history, it should only be noted that the most recent Reorganization Act (1965) abolished the statutory requirement for the divisional committees. Since they did not report to the Board, the Board did not vote on the desirability of this change.

Now the question, should the Board become advisory only, must be faced again. My own personal opinion is that the Board should not be reduced to the status of an advisory board only. However, to discharge its functions it is going to have to work harder and more efficiently than it has been able to do in the past few years. It has reorganized itself, but it will require some competent full-time help reporting to the Board through its committee chairman to dig out the necessary facts and to help the committees formulate policy. The Board should be given a few more years to see if it can satisfactorily live up to the high expectations its founders had, and to see if it can discharge its duties. If it cannot, obviously a new arrangement, with congressional

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[1] From minutes of NSB meeting 77, May 17, 1962:

(1) To the new Office will be transferred from the Foundation as follows: (*a*) the first part of sec. 3(a)(6) of the NSF Act as amended, namely: "to evaluate scientific research programs undertaken by agencies of the Federal Government * * *"; and (*b*) so much of the authority of sec. 3(a)(1) of the act "to develop and encourage the pursuit of a national policy for the promotion of basic research and education of a national policy for the promotion of basic research and education in the sciences" as will enable the Director of the new Office "to advise and assist the President in achieving coordinated Federal policies for the promotion of basic research and education in the sciences."

(2) The Director will become a full voting member of the Board.

(3) The Executive Committee of the Board will be composed of five voting members, four elected from the Board and the Director of the Foundation who will serve as Chairman.

(4) The divisional committees will report to the Director rather than to the Board and the Director.

approval, must be found. That arrangement would probably reduce the Board to an advisory one.

8. What is the Board's fundamental policy with respect to NSF fellowships and grants to universities and colleges? Is your policy aimed primarily at supporting scientific research on the campus, and secondarily at the education of students and the training of science teachers; or is it vice versa?

8. The Board's fundamental policy with respect to NSF fellowships and grants to universities and colleges derives from the Foundation's statutory mandate to initiate and support basic research and scientific research potential in all fields of science (including engineering). The operation of this policy (which has never been further codified) is characterized by the following principles: (1) awards will be made to support the work of individuals of high merit to enable them to undertake activities of high quality; (2) research is enhanced when it also provides training for graduate students, recent postdoctorals, etc.; (3) if it is to be fully effective, graduate education must be associated with high-quality research; (4) research and education are closely intertwined on university campuses and should not be thought of as competitive activities. Having said this, however, let me draw specific attention to the fact that the Foundation's teacher training activities, its course content improvement work and all the rest of its science education programs are based in the last analysis on the conviction that, by making our science education better we will thereby assure (in the long run) more and better research.

I do not think it would be a profitable exercise to rank the research and education responsibilities of the Foundation, especially as they apply to university and college activities in the pursuit of basic research. Both activities must be viewed as being of the highest priority and of equal status in fulfilling the mission assigned to the Foundation by Congress.

9. What is the Board's view regarding the stationary level of the NSF staff over several years when its own funding and that of Government has sharply grown? Is the staff assistance provided for the Board satisfactory?

9. The Board has never concerned itself particularly with the number of personnel and the grade level of the Foundation's staff, assuming that they were of an administrative nature and therefore the responsibility of the Director. However, it is quite evident that at the highest levels (the only ones with whom I came in contact), many are extremely hard pressed and probably overworked.

The secretariat of the Board is quite satisfactory.

However, it is my opinion that if the Board is to really make studies on which policy can be based, its own staff must be considerably augmented. This augmentation must be with full-time people whose primary job is to serve the Board in this capacity.

10. In what areas should NSF exercise its existing authority further? What new roles do you foresee for the Foundation over the next 10 years and what new authority seems warranted, as for example in areas of applied research and engineering?

10. I think that there are a number of areas in which the National Science Foundation should exercise its existing authority further. These are in the area of the relationship of science and engineering

to problems which fall in the public domain. To conduct design and engineering studies on unique systems which do not come under the purview of private industry—e.g., weather modification, transportation, water retrieval, et cetera. However, it is doubtful that these will be undertaken unless the Foundation is specifically directed to do so by the Congress.

11. Could you give examples of policy guidance developed by the Board—especially to distinguish between its passive role of endorsing NSF staff proposals and an active role of taking initiative?

11. Two most recent examples are the development of policies by Board Committees which were subsequently approved by full Board as follows:

(*a*) "The Role of the National Science Foundation in Support of Research in Ground-based Astronomy" proposed by Committee III and approved by the Board at its 100th meeting (May 1965) is as follows:

The hope of understanding of the universe in which man finds himself is one of the most exciting prospects of our time. Man yearns to understand how the universe came into being, what forces and phenomena resulted in the dispersion of matter which has been revealed to date. How old is it? How large is it? How far are the starts? Of what are they made? What is the source of the energy which comes to us? These are age-old questions, the answers to which seem potentially available as a consequence of intensified efforts using the refined techniques of modern astronomy. For many years to come, adventures in cosmology and astrophysics will exercise enormous intellectual appeal. The continuing acquisition of increasingly detailed and sophisticated astronomical information will provide scientists and laymen opportunity to develop some understanding of the universe in which he lives. In our view, such understanding more than justifies the effort and costs essential to its attainment.

The Whitford report.—In preparation for this effort a panel of astronomers, chaired by Dr. A. E. Whitford, issued a report, through the Committee on Science and Public Policy of the National Academy of Sciences, which contains a series of recommendations for the addition of new optical and radio telescopes to the national armamentarium. This report limited itself to a timetable for the acquisition of new telescopes, of various sizes, while ignoring the costs of their operation, the costs of current programs in astronomy and their possible expansion, development of new auxiliary equipment for conventional telescopes, the special requirements for observations of the solar system by the National Aeronautics and Space Administration, solar astronomy, and the possible elaboration of space-based astronomy. Insofar as this Committee, and other inquiring groups have been able to ascertain, the response of the public and scientific world to the report has ranged from receptive to enthusiastic and in general has been very favorable.

Interagency assessment of the Whitford report.—As a step toward evaluation of the specific recommendations of the Academy report, the Director of the Office of Science and Technology requested the Director of the Foundation to establish an ad hoc group of representatives of those Federal agencies with an interest in the support of ground-based astronomy for the purpose of assessing the Whitford report. This Interagency Committee was chaired by Dr. Geoffrey Keller. Dr. Keller's committee examined the specific recommendations of the Whitford report and accepted their validity as a basis for planning. They attempted an assessment and anlysis of the full costs which would be incurred by the various Federal agencies over the next decade if all the recommendations in the Whitford report were to be implemented. Further, the Interagency Committee estimated the cost of continuing all federally supported programs for research in astronomy already underway with particular attention to the needs of astronomers located at universities which are not directly associated with major astronomical observatories. Thus, the Interagency Committee attempted an assessment of the totality of "small science" in astronomy as well as the new costs of "big science" as recommended by the Whitford panel.

Appendix I summarizes the total expenditures for ground-based astronomy which the NSF might expend over 12 fiscal years as projected by the Division of Mathematical and Physical Sciences staff from the interagency report.

Appendix II presents a tentative total Federal budget for the support of ground-based astronomy as prepared by the Interagency Committee.

Appendix III presents a tentative detailed budget for the total support of ground-based astronomy by the Foundation, based upon the allocations and projections of this Interagency Committee.

Questionnaire to the community of astronomers.—In an attempt to establish the validity of the initial recommendations of the Whitford report, Committee III sampled the community of astronomers by posing a series of questions to a selected group of 17 astronomers currently supported by the Foundation. The results of this inquiry have satisfied the Committee that the recommendations of the Whitford report are sound in that they project a national program which is within the capacity of the American community of astronomers and which, if implemented, would provide for a vigorous national program while not satisfying all of the requests of any segment of this community.

RECOMMENDATIONS TO THE BOARD FROM COMMITTEE III

A. *On the implementation of the Whitford and interagency reports.*—After examination of the Whitford report, the report of the Interagency Committee, and replies of practicing astronomers to its own questionnaire, Committee III has studied the plans of the Division of Mathematical and Physical Sciences of the Foundation for the support of ground-based astronomy over the next decade as summarized in appendix I which is derived from documents NSB/C–III–65–12:11–16, appendix B (auxiliary table VIII, actual and planned funding by NSF for various budget categories). Committee III considers these projections to be reasonable and appropriate as goals toward which the Foundation should strive.

Accordingly, Committee III endorses the general plans of the MPS Division with respect to ground-based astronomy and recommendts their approval.

Such approval must be accompanied by the caveat which the Director provided to the Director of the Office of Science and Technology concerning the assessment of the ad hoc interagency group:

"* * * as the Foundation develops its specific future plans for this field, it must, of course, give equally specific attention to the needs of other sciences. With this reservation, however, I believe that the Foundation's role should be along the lines suggested in the assessment, subject of course to the availability of funds for this and all other activities for which we are responsible."

(*a*) It should be noted that the support of university-based research in astronomy as outlined in the MPS plan provides for growth at about 15 percent per year. The funds in this plan which relate to university-based astronomy research shall be considered as flexible and shall be used to facilitate the most appropriate expansion of the Nation's capabilities in basic ground-based astronomical research as circumstances dictate.

(*b*) In seeking appropriations to implement the overall plan, major capital equipment items should be presented as budgetary line items in order (1) to assure visibility to Congressional Appropriations Committees and (2) to minimize competition between such requests and the Foundation's continuing needs for its normal appropriations.

(*c*) Appropriations for funding minor capital equipment should be achieved from the general research projects appropriation to the Foundation and should be defended and justified in competitive fashion as in all other fields of science in the manner normal to NSF operation.

(*d*) Each item of major capital equipment should be supported by the Foundation only after its provision has been given specific scientific justification and the Foundation is assured that a highly qualified scientific user's group will assure competent use and operation of such a facility.

(*e*) In the event that appropriations are insufficient to fund all requested new major facilities, priority among them should be given to those which provide new capabilities beyond those of existing instrumentation.

(*f*) The annual award in support of any major astronomical facility may provide for the necessary operating and maintenance costs thereof, plus additional funds required for the specific projects proposed by the staff of said facility which would permit use, by that staff, of a reasonable fraction of the time on that facility. The remainder of costs should be funded by

a combination of direct support to the facility and grants going directly to the institutions of guest scientists based elsewhere than at the facility.

In general, the latter grants will support the research programs of this group of scientists both at their home bases and at the facility.

B. *On the concept of a "principal Federal agent" for a scientific discipline.*— The progress of certain fields of science is closely related to the successful accomplishment of the specific missions of certain Federal agencies. Among such instances may be noted high energy physics (AEC), materials research (ARPA), health related research (NIH), and space-based astronomy (NASA). This has led, rather naturally, to the assumption by these agencies of responsibility for the welfare of their related scientific fields for which they presently provide the predominant Federal source of funds. The Foundation is also the predominant supporting agency for a series of scientific fields for which no other natural alliance is evident, e.g., taxonomic biology, research in the Antarctic, deep crustal studies, as well as much of mathematics, physics, and chemistry.

Other fields of science have found support from a diversity of Federal agencies, no one of which has assumed, by practice or policy, responsibility for assuring their continuing welfare, e.g., ground-based astronomy and much of chemistry. Under these circumstances, there is danger that the relative vitality of these fields may be jeopardized for lack of a single agency which assumes responsibility for coordination and planned support.

Under the latter circumstances, in order to assure the continuing vitality of each such discipline, it appears appropriate that a specific Federal agency be publicly recognized as the principal Federal agent for that area of science. It is implicit in the role of a principal Federal agent that (1) the agency staff must include individuals who are well versed in the field, its techniques, accomplishments, and aspirations; (2) the principal agent accepts responsibility for a major share of Federal financing of that field; (3) the agent and its staff must be vigilant with respect to the continuing health of the national program with regard to that field of science and should, as circumstances require, undertake to elicit and stimulate support from other Federal and private agencies for those aspects of the field which can appropriately be supported within the recognized missions of those agencies; (4) the principal agent should assume responsibility for preparation of an annual report to the Office of Science and Technology and to the Congress on the progress of the area of science for which it has accepted responsibility and on the total financial support for that field from all branches of the Federal establishment and from the principal non-Federal sources.

Responsibility for the prime support of astronomy is entirely compatible with the broad mission of the National Science Foundation—the health, vigor, and development of the total national scientific enterprise. This role was essentially accepted, pari passu, when the Foundation undertook support of NRAO and of KPNO.

For many years to come, ground-based astronomy will remain an important and exciting frontier of science. Although space-based astronomy will introduce many new techniques, such developments predictably will create additional, rather than lesser, interests in and need for research in ground-based astronomy. Although NASA will continue to have great involvement with space-based astronomy, no Federal agency other than the Foundation is a natural base for support of ground-based astronomy.

Accordingly, the committee recommends that the National Science Foundation should offer to assume the role of principal Federal agent for ground-based astronomy.

APPENDIX I

NSF expenditures for astronomy, fiscal years 1965–76

	Millions
A. Acquisition of Whitford Facilities, Operation of Whitford Facilities	$224.8
B. Kitt Peak National Observatory	48.7
C. Cerro Tololo Inter-American Observatory	20.3
D. Arecibo	13.3
E. National Radio Astronomy Observatory	81.1
F. University based—General	141.2
Total	529.4

APPENDIX II

Summary of recommendations by interagency group

[In millions]

	Whitford report recommendations (A)	Plan proposed in this assessment: Funds to build and operate W.R. recommended facilities (from table I) (B)	Plan proposed in this assessment: Funds for support of all activities in ground-based astronomy (from table VII) (C)
Fiscal year:			
1965 (actual)		$7.6	$25.5
1966 (planned)		24.0	33.9
1967	$12.4	23.7	57.6
1968	19.4	25.9	63.1
1969	24.0	40.1	80.3
1970	26.1	31.5	75.2
1971	26.2	26.1	73.7
1972-76	115.9	118.5	430.4
Total	224.1	[1] 297.4	839.7

[1] This estimate does not include the cost of supporting the scientists who would, as visitors, use the larger telescopes listed in table I. It is anticipated that all the instruments in the category optical, large telescopes, a few in the category optical, intermediate-sized telescopes, and, among the radio telescopes, the high resolution array, the 8-antenna mobile array, and the 2,300-foot steerable telescopes would be available for use by visitors approximately half of their operating time. It is estimated that the Federal funds for support of these users, including their students, special equipment, travel, and other expenses associated with the part of their research efforts based on use of the large telescopes as visitors would cost, over the same period, between $6,000,000 and $8,000,000. This user cost has already been included, however, in the estimates in the right-hand column.

AUXILIARY TABLE VIII.—*Actual and planned funding by NSF for various budget categories, itemized by facility or other purpose*

[In millions of dollars]

Funding agency and purpose	Actual, fiscal year 1965	Planned, fiscal year 1966	1967	1968	1969	1970	1971	1972–76	Total
NSF (KPNO):									
150-inch telescope [1]	1.9		7.4						9.3
Operation [1]								(1.8)	(1.8)
84-inch telescope							2.6		2.6
Operation								(.2)	(.2)
Reflecting coronagraph				0.3					.3
Operation								(.2)	(.2)
Feasibility study for largest feasible reflector [2]			.3	.3	0.3	0.3	.3		1.5
Other ground-based capital and operation	2.3	2.8	3.6	3.3	4.2	4.2	4.5	23.3	48.1
Total KPNO, ground based	4.2	2.8	11.3	3.9	4.5	4.5	7.4	25.5	64.1
Space astronomy program	2.7	3.5	3.7	3.9	4.1	4.2	4.5	25.5	52.2
Total KPNO	6.9	6.3	15.0	7.8	8.6	8.7	11.9	51.0	116.2
NSF (CTIO):									
200-inch telescope [3]				2.0	21.0				23.0
Operation [3]								(0)	(0)
Other capital and operation	1.3	.9	1.8	1.5	1.5	1.6	1.7	10.0	20.3
Total CTIO	1.3	.9	1.8	3.5	22.5	1.6	1.7	10.0	43.3

See footnotes at end of table, pp. 1339, 1340.

AUXILIARY TABLE VIII.—*Actual and planned funding by NSF for various budget categories, itemized by facility or other purpose*—Continued

[In millions of dollars]

Funding agency and purpose	Actual, fiscal year 1965	Planned, fiscal year 1966	1967	1968	1969	1970	1971	1972–76	Total
NSF (NRAO):									
Very-large high-resolution array:									
Design and construction [4]	0	.2	2.0	12.0	10.0	8.0	7.8	0	40.0
Operation [4]					(.4)	(2.8)	(4.8)	(38.4)	(46.4)
Very large paraboloid: Feasibility and engineering study [5]	0	.1	.2	.7					1.0
Other, capital and operation	3.3	4.8	5.3	5.8	5.9	6.5	7.0	42.5	81.1
Total NRAO	3.3	5.1	7.5	18.5	16.3	17.3	19.6	80.9	168.5
NSF (university astronomy research facilities):									
Optical:									
60-inch reflecting telescope		1.0							1.0
Small modern telescopes at universities [6]			.2	.2	.3	.3	.4	2.0	3.4
Radio:									
Owens Valley Observatory 8 antennas [7]	1.6			3.6		4.8			10.0
2 300-foot steerable telescopes [8]			8.0			8.0			16.0
Small instruments at universities			.2	1.4	1.7	.5	2.2	24.0	30.0
Total, university facilities	1.6	1.0	8.4	5.2	2.0	13.6	2.6	26.0	60.4
NSF (basic research):									
Optical: Telescope operation						.1	.2	1.4	1.7
Radio:									
Operation, large telescopes (Owens Valley and 2 300-foot telescopes)			.3	.3	.3	1.0	1.5	14.0	17.4
Operation, Arecibo telescope [9]		.3	.6	.9	1.2	1.3	1.5	7.5	13.3
Operation, small telescopes [10]				.1	.4	.8	1.0	5.5	7.8
General:									
Auxiliary instruments	.2	.5	.6	.7	.8	.9	1.0	7.0	11.7
Support of other basic research at universities	3.8	6.0	6.9	7.8	8.7	9.6	10.9	87.5	141.2
Subtotal, support of basic research excluding operation of large telescopes [11]	4.0	6.5	7.5	8.6	9.9	11.4	13.1	101.4	162.4
Total, basic research [12]	4.0	6.8	8.4	9.8	11.4	13.7	16.1	122.9	193.1
NSF, total	14.4	16.6	37.4	40.9	56.7	50.7	47.4	265.3	529.4

NOTES

[1] Maintenance and operation costs estimated at $150,000 per year; auxiliary instrumentation estimated at $200,000 per year for total operating cost of $350,000 per year starting 1972.

[2] No construction or operating costs included.

[3] Total operating costs start 1979.

[4] For overall annual operating rates of smaller radio astronomy facilities (excluding users' costs) the figure of 25 percent of capital cost has been used. In the case of the very large array it has been assumed that the elements of the array will come into operation gradually over a 10-year period, and that the operating costs will increase accordingly over this period. Maintenance cost of such an instrument will certainly increase with the number of elements, but to the extent that it is used as a single observing system, the number of scientists which will be able to use it in the course of a year will probably not increase as rapidly. With this in mind the operating cost has been calculated at a rate of 20 percent of capital cost instead of 25 percent. To a considerable extent the quantity and sophistication of the data which can be obtained from the array will depend on the level of operating support which is provided.

[5] No construction funds have been included in this plan pending the completion of the feasibility study. Study cost schedule is that suggested by NRAO.

[6] Includes both Government in-house efforts shared by universities and university instruments. It is hoped that the cost of NASA- and NSF-supported purchases will be shared to some extent by the recipient institutions but it is difficult to estimate the amount of such contributions. This item will also provide for some telescopes smaller than 36 inches (the definition of this class in the Whitford report). The total number of telescopes provided will depend on size, but assuming an average cost of $500,000, some 17 or 18 could be supported, or more if cost is shared by the institutions.

[7] These 8 dishes will be added to the 2 existing 90-foot dishes currently being used as an interferometer. The fiscal year 1965 funding provides for 1 additional 130-foot dish, the fiscal year 1968 funding is intended to provide 3 more, and the fiscal year 1970 funding the remaining 4. Current support is from ONR at $250,000 per year. The operating funds indicated in the table are intended to cover increased operating needs as the additional dishes come into operation. Some of this additional support may be provided by ONR. For the reasons given in note 4, the additional operating cost has been calculated at 20 percent of the additional capital cost.

[8] Total operating cost (not including users' costs) estimated at $500,000 per year.

[9] It has been tentatively agreed that NSF will share the cost of operating this installation, particularly with regard to the radio astronomy research done at this station, with DOD.

(Continued at foot of p. 1340.)

(*b*) "Use of Digital Computers in Universities and Colleges," proposed by Committee I and adopted by the Board at its 100th meeting (May 1965) is as follows:

Committee I has considered the role of the National Science Foundation in the oncoming activities in the Nation's colleges and universities based on the use of digital computers. Most of these activities are presently supported by the Federal Government. The need for these machines is expected to continue to grow so fast that the costs, and supporting elements, such as skilled manpower, Federal administration, etc. involved in their use may soon become major items in the resources available for national science and engineering training and research. The shape of this climbing curve of usage was foreseen by the Director of the National Science Foundation, Dr. Alan T. Waterman, when he requested the National Academy of Sciences-National Research Council in June of 1962 to undertake a broad study of the needs of colleges and and universities for such computers. This study, being performed by a distinguished group of experts, has not yet been completed, although it may appear in the coming summer; it has been surveyed by the Committee on Science and Public Policy of the National Academy of Sciences. Committee I is pleased to have been able to review a preliminary draft of this report. The Committee has benefited by regarding certain dimensions quite firmly established by the report, such as the 45-percent annual growth curve of the capital cost (i.e., "purchase value") of computers presently at universities and colleges. This has led to a present figure of about one-quarter billion dollars capital investment without discount or depreciation. Also, the annual staff costs are apparently one-fifth or one-quarter of this overall figure and are rising rapidly. Indeed, the aforementioned Committee on Uses of Computers, chaired by Dr. J. Barkley Rosser of the University of Wisconsin, estimates that the total annual costs, based on just equivalent annual rental corresponding to the capital value mentioned earlier, are already $137 million and will rise by 1968 to about $236 million. When it is recalled that this figure would perhaps exceed our total NSF basic research project grant figure and, indeed, compares with half the total Foundation budget, we can appreciate what this university and college computer activity represents. The important thing is that although the largest part of this usage cost is already devoted to scientific and engineering research along the lines of the Foundation's major mission, these costs reflect only the barest beginnings of the very large role that digital machines will have in education itself, and in many parts of science and technology in universities which are now barely involved.

Beyond these dimensional features, Committee I has also had in mind the national policies reflected in the President's report to the Congress of March 2, 1965. In this, the Bureau of the Budget has carried out a study of use of automatic data processing machinery within the Government itself. The history of this usage is also instructive for the considerations of the National Science Board. The report asserts that in 1954 the Government had used a total of 10 computers and that today, excluding military operations and security uses, it employs directly 1,800 computers at a cost of about $1 billion annually. It is further estimated that 3,600 more computers are used in special security and military operations, including those of private contractors used on a cost-reimbursement basis. It was believed that this represents about $3 billion more in annual cost. Now, evidently an operation of this importance and magnitude will attract much attention administratively throughout the Government, and it is therefore particularly important that complex and unconventional use of these equipments, such as may be expected in universities and colleges, be managed so that undue restraints arising from the massive costs of the total Federal program will be avoided. The President's message, for instance, accents questions of centralized computing centers for more efficient utilization of equipment, problems of purchase versus rental, standardization of equipment (and, hopefully, of software—programing facilities, etc.) and so on. The study and the Presi-

[10] Operation costs of many existing university radio telescopes appear below in the item for "Support of other basic research at universities."

[11] Numbers in this line have been adjusted to reflect-pe a 15rcent increase annually starting in 1967. Costs of support of balloon astronomy are included.

[12] The 1965 and 1966 figures exclude astronomy basic research funds allocated to support rocket astronomy research at the E. O. Hulburt Center at NRL. It should be remarked that the method of obtaining this total reflects the assumption that the support of basic research at universities, including the users of large facilities (calculated to increase at 15 percent per year) should not be required to carry the cost of operating large telescopes.

dent's message avoid the temptation of proposing a separate central office for the procurement and utilization of electronic computers and, indeed, emphasize the responsibility of various agencies to control their own costs and operations. Basic in all these considerations is the compelling requirement for more trained personnel and sophisticated operators and users. This educational program alone requires and deserves a major effort.

Cognizant of these various factors, but impelled chiefly by the great opportunities in the use of electronic computers for the advance of human knowledge and, especially, by the chance they offer for the liberation of creative minds from the demands of routine data and pattern analysis, Committee I forwards the following position:

1. Automatic information processing machinery, particularly electronic digital computers, are essential aids to modern research in science and engineering. Such facilities will probably become important in the methodology of education as well (through information retrieval, display, bibliographic function, etc.). Accordingly, universities and colleges (as well as other institutions which sponsor research and learning in science and technology) should have appropriate computing facilities. The need for quantity and quality of such facilities should be demonstrated on an analogous base of merit and opportunity as has been applied for Federal support of research and education in science and engineering in these institutions.

2. The National Science Foundation should assume a general responsibility in the Government for monitoring and encouraging appropriate development of these facilities and their use in universities and colleges. This policy does not specify the proportion of total financial support to come from the National Science Foundation, since other agencies may have special reasons for very extensive support in particular situations and, in any case, the well-known national policy of diversity for research funding applies in this case. However, in terms of its statutory mission to assure the vigor and progress of basic research and education in the sciences, the NSF should undertake to see that automatic data processing facilities become extensively and increasingly available to American institutions of higher learning.

3. Accordingly, in collaboration with the Director and staff of the NSF, Committee I has proposed that certain task forces be activated promptly to gather information for preparing to submit to the National Science Board, various policies which would activate the aforementioned role of the National Science Foundation.

4. Particularly, these task forces include—

(*a*) A group having interagency associations which will seek to identify the current university computer support in terms of the Federal agencies and fundings;

(*b*) A group which will study the accounting and fiscal aspects of controls relating to computer support in universities and colleges. This group, which will be primarily comptroller officials of various agencies, will consider such problems as the requirement that all academic users, sponsored or nonsponsored, be charged at the same rate. It will be also concerned with the rent-versus-buy questions and other elements of the Federal policy.

(*c*) A group of experts in computer systems design and usage, from Government, universities, and industry (perhaps not the computer industry), who will assess the opportunities for organizing facilities for academic use. This is so that the many options can become known to the many institutions which may be acquiring facilities. Thus, centralization, input-output stations, graphic displays, etc., should be surveyed, and recommendations made for the best overall (but flexible) approaches.

RUFUS E. CLEMENT.
KATHARINE E. MCBRIDE.
EDWARD J. MCSHANE.
ROBERT S. MORISON,
Vice Chairman.
WILLIAM W. RUBEY.
EDWARD L. TATUM.
ERIC A. WALKER.
W. O. BAKER,
Chairman.

12. Are the goals of the Gilliland reports still valid? How is the NSF fulfilling its responsibilities to meeting these goals?

12. The Gilliland Panel recommended the following goals:

1. To increase the number of doctor's degrees awarded each year in engineering, mathematics, and the physical sciences (EMP fields) to reach 7,500 in 1970. Percentage increases are intended to be greater in engineering than in other EMP fields.
2. Increase the number of students who complete a full year of graduate training in the EMP fields to reach 30,000 during 1970.
3. Encourage the strengthening of existing centers of excellence in the EMP fields and develop new centers of educational excellence.
4. Promote wider geographic distribution of centers of educational excellence.

It is my opinion that these goals are still valid and will remain valid for at least another 5 years.

The National Science Foundation is moving to fulfill its responsibilities in reaching these goals. Perhaps the money has not been sufficient to take the step forward that many educators believe is necessary. Nevertheless, in fiscal year 1964 approximately 1,200 traineeships were established in engineering. In fiscal year 1965 approximately 2,800 traineeships were granted in engineering, mathematics, and physics. This number is lower than it should have been. Of this 2,800, there were 1,800 in engineering and the others were in mathematics and physics. Unfortunately, the 1,800 in engineering allowed about 900 of the original 1,200 engineering trainees to continue into their second year, and the number of new first-year traineeships was reduced from 1,200 to about 700. This produced considerable unhappiness among engineering educators. However, the problem is one that only money can solve.

13. Are too many Federal agencies today involved in supporting basic science grants and science education? Might not the Foundation assume a more central, or perhaps an exclusive role in this regard?

13. It is my own personal opinion that this is so; that many of the things that are done under other agencies could well be done under the National Science Foundation. However, these could not be done without an increase in the numbers of the National Science Foundation staff and a strengthening of the National Science Foundation Board.

14. What is the Board's policy with respect to geographical dispersal of institutional support? Has there been any effective dispersal? What has the Foundation done in response to the 1960 report of the President's Scientific Advisory Committee which advocated additional centers of academic excellence?

14. The first two-thirds of the Foundation's operational history was concerned with the establishment of effective programs for identifying highly qualified individuals who might be assisted in undertaking highly meritorious science projects. During this earlier period, geographic factors played a secondary role to such qualitative considerations. In the last third of the Foundation's existence, however, institutional support has taken on added importance and geographic dispersal has been recognized as a vital element in such support. The Foundation's institutional base grants program with the "tapered

formula" attached to such support, while it is not directly tied to geography, has tended to insure a spreading of institutional support.

The Board has over the years become increasingly concerned about the need for recognizing geographic factors in providing institutional support. Institutional support activities, including the science development program, have been initiated by the Foundation with Board encouragement and approval. The science development program, which now has made major institutional strengthening grants to 10 universities in widely dispersed areas, is in direct response to the 1960 recommendation of the President's Science Advisory Committee.

The Board has established a special committee of its members to provide continuing review of the science development program. The Board is also considering what other steps can be undertaken to identify and strengthen institutions and departments of high science potential. The Foundation is still in the early stages of these programs, but they should have an important effect in attaining added scientific strength in the different geographical areas of the country. It is too early to claim "effective dispersal" of institutional support, but these newer programs of the Foundation are certainly pointed toward such a goal.

15. A dropout problem exists for students of science and engineering as well as other subjects. What should the NSF do to study the reasons for dropouts in secondary schools and colleges? Should it take a mission interest and actively seek to interest investigators in such studies, or should it wait and hope that some scientists will become interested on their own and submit suitable proposals?

15. I do not regard this as a problem for the National Science Foundation. Although one might say that research in education could come under the aegis of the Board, I believe it would be better done under the Office of Education. Although there might be a science of education, the Office of Education is more likely to give it the proper priority than is the National Science Foundation.

16. Should the Foundation's national laboratories and, for that matter, the large laboratories of other departments, such as the AEC Argonne National Laboratory, be treated as permanent national scientific assets to be indefinitely maintained, or should their continued existence depend upon the current vitality and importance of the fields of science in which they excel? Should they have an indefinite mortgage upon future resources for science? If so, what should be their role as efforts and attention of scientists change to new fields?

16. I do not think so. I do not think that any laboratory should be maintained when the scientific field in which it is interested has dried up. In such instances (and I am not sure that there are any in existence at the present moment), the laboratories should be closed, the programs tied off, the people allowed to seek newer and more exciting projects elsewhere, and if necessary, the physical facilities should be mothballed until there is another need for them.

17. What is your opinion about the proposal that annual funding for NSF-supported basic research be increased by 15 percent annually to accommodate entry of new scientists into independent research and to cover the increased cost of equipment? Do you see graduate schools capable of accommodating a continually growing graduate student

body in the sciences? Can the undergraduate colleges be expected to produce more students each year for graduate study in the sciences?

17. I am in complete agreement that the annual funding for NSF-supported basic research should be increased by 15 percent annually. The Board, as a whole, did discuss this problem and, I believe, are in complete agreement. Moreover, we do feel that the graduate schools will be capable of accommodating a continually growing graduate student body if the necessary fellowships and the necessary basic research funds are forthcoming. Moreover, the undegraduate colleges can be expected to produce more students for graduate study in the sciences, at least until the eighties when there might be a slight reversal. However, this is far in the future and is something which can be better assessed as the time draws near.

18. Exactly how do you make use of the Science Information Exchange?

18. The Science Information Exchange evolved from earlier Government information exchange mechanisms which were originally created to maintain information on current research projects and proposals for research support. These mechanisms were devised, first in the biological and medical sciences, to provide coordination of agency support and avoidance of unnecessary duplication by means of a common file of information which could be called upon by Government science administrators. The earlier mechanisms evolved with the increase in Federal support into a larger, more comprehensive system. Today SIE covers both the life sciences and the physical sciences, and some aspects of the social sciences. It includes information on current projects, research proposals, and in some cases subtasks of larger projects. It incorporates activities in basic research, and some aspects of applied research and development. These data are being provided on a periodic basis, throughout the year, to SIE. Furthermore, it contains within its files, which are now partially computerized, information from both Government and private sources.

The Science Information Exchange is still primarily a tool for Government research administrators to aid in the coordination of Government research support. Agencies place their support activities into the files of SIE, which are collated, organized, and stored for retrieval, and program directors and their equivalents call upon these data for checking related activities when considering requests for research support. The physical, engineering, and social sciences coverage within SIE is a relatively new activity. These data are now being handled in much the same way as the biological data are handled, but the SIE files in these newer areas are not as complete as those in the biological sciences. As the SIE files increase, the total cost of maintenance and operation also increases, but the unit cost, of course, is reduced.

The mechanism of use is relatively simple. A program director requests, by use of descriptors, information out of the SIE file for his use. These descriptors are codes or keys under which the data within the files have been stored for rapid retrieval. The effectiveness of the system is directly dependent upon the types of descriptors used as related to the requirements of the users within the Government agencies. The quality of the response, of course, is also dependent on the completeness of the file and the adequacy of the retrieval

system. The problem of an optimum storage and retrieval system for these data is still under study.

I recent years SIE has been providing information from its files to non-Government requestors, principally scientists and institutions. Thus, a semipublic information service has been developing, and the demand for such service has been increasing. The service is somewhat similar to that provided to program directors, although more limited. A qualified requestor may ask for information on a subject or area of interest and receive information from the system. The costs of such an added service are not fully understood, since at present they are treated as "add ons" to the service now being given to Government agencies. This added function has, of necessity, affected the techniques of storage and retrieval. The relationship of this semipublic service to the Government service is also not completely understood and is under study.

19. What attention has the Board given the statistical and analytical functions of the Foundation for scientific and technical manpower? How would the Board propose to speed up and better adapt the statistical services to the needs of the research and policymaking communities?

19. A recent reorganization of the Foundation's planning activities, including the staff groups responsible for the statistical and analytical functions, has served to focus and emphasize the Foundation's special role in these areas. The Board has reviewed and endorsed this reorganization. The Board, moreover, has had an opportunity to become thoroughly familiar with the character of expanded activities planned for the future in relation to the Foundation's statistical and analytical functions. In addition, a Board committee concerned with long-range planning has been established which we anticipate will provide special guidance for the Foundation's statistical and analytical functions through the identification of its own special needs for information and analyses. The Board's composition is in part representative of the research community as a whole. Many of its members are part of or in close touch with policymaking communities. It can be said, therefore, that the Board is in fact a reasonably effective vehicle for representing to the Foundation the needs of these communities.

The statistical activities of the Foundation cover a broad spectrum of data collection and analyses, from both Government and private sources, covering research, development, economic implications, financing, capitalization, institutional commitment, and manpower dynamics. It is no exaggeration to characterize these activities as providing the United States with the best information of this type in the world. This is not to say that there could not be improvement in this activity, especially in the timeliness and utilization of these data. Recently, important steps have been taken to achieve such improvement. The fuller utilization of data processing equipment will help considerably in speeding the analytical and publication process. This will, in turn, insure improved services to the research and policymaking communities.

Response by Dr. William T. Knox, Chairman, Committee on Scientific and Technical Information, Federal Council for Science and Technology, to Questions of the Subcommittee on Science, Research, and Development

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1. Section 902 of Public Law 85–864 established a statutory "Science Information Council" to advise the National Science Foundation in relation to its then new Science Information Service function.

(*a*) *What is the relationship of this Council to—*

The Office of Science and Technology (*OST*)?

Committee on Scientific and Technical Information (*COSATI*)?

The President's Science Advisory Committee (*PSAC*)?

Federal Council for Science and Technology (*FCST*)?

National Science Board?

1. (*a*) The Science Information Council has no statutory relation to OST, COSATI, PSAC, FCST, or the National Science Board. It gives advice to the Head, Office of Science Information Service, in the National Science Foundation. The Chairman of the Science Information Council has, for the last several years, attended the annual meetings of the Advisory Committee Chairmen held by the Director of the National Science Foundation. There is no continuing liaison by the Science Information Council with any other Government agency or organization.

(*b*) *In your judgment where should basic statutory responsibility for Federal science information services reside?*

(*b*) In my judgment, each and every Federal department and agency concerned with science and technology should have a basic statutory responsibility for insuring a healthy, effective, information service within its sphere of responsibility. As in the case of other functional areas within science and technology, such as national policies for support of basic research, the Federal overall responsibility resides in the Office of Science and Technology.

(*c*) *How is this currently split between NSF, OST, and the Clearinghouse for Federal Scientific and Technical Information?*

(*c*) The Clearinghouse for Federal Scientific and Technical Information, operated by the Department of Commerce under the National Bureau of Standards, was created, under Public Law 776, to provide a central organization through which the public can obtain copies of scientific and technical reports generated by the Federal Government and its contractors. The Clearinghouse has brought to a single organizational focus, and has made more conspicuous the Government's activities in the physical and engineering sciences. A major Federal operating responsibility for information dissemination is thus being executed by the Department of Commerce.

Neither OST nor NSF have operating responsibilities like the Clearinghouse. The National Science Foundation carries out certain functions in support of scientific and technical information, as outlined in my testimony of July 27. The NSF also has management responsibility for the Science Information Exchange and the National Referral Center. It carries major responsibilities for providing liaison between the Federal Government and the professional scientific and engineering societies. The overall leadership for Federal scientific and technical information activities rests with the Office of Science and Technology, as was intended by Reorganization Plan No. 2 of 1962.

2. Supplementing your testimony of July 27, how will the development of the new Clearinghouse for Federal Scientific and Technical Information, under the National Bureau of Standards, affect the responsibilities of NSF for scientific information dissemination? Will there be duplication? Has the NSF lost one of its original functions?

2. Insofar as the Clearinghouse distributes copies of Federal reports to the general public, its operations do not affect the responsibilities of NSF for scientific information dissemination. NSF has consistently encouraged the establishment of the Clearinghouse under its legislative mandate (title IX, National Defense Education Act of 1958) to provide, or arrange for the provision of, the functions necessary for more effective information dissemination. In 1958, for example, NSF transferred funds to the Department of Commerce to expand its acquisitions of technical reports and to speed the production and expand the coverage of the abstract journal, "U.S. Government Research & Development Reports." During the period 1958–61, NSF also chaired a series of meetings with representatives of Commerce and other Federal agencies producing technical reports which resulted in all agencies agreeing to make their unrestricted, unclassified technical reports available to the Clearinghouse.

3. A new Standard Reference Data System directed by the Bureau of Standards is being developed in order to centralize the collection, evaluation, organization, and distribution of scientific data in all fields.

(*a*) *Is this system to be used by the Bureau of Standards' new Clearinghouse?*

(*b*) *Will it decrease the amount of duplication of scientific information dissemination and storage in other Federal agencies?*

(*c*) *What is the relative role of NSF to the system?*

3. The National Standard Reference Data System (NSRDS), managed by the National Bureau of Standards, is restricted to the critical evaluation of selected numerical data in fields of science and technology. The products of this effort will mainly be printed documents, and these will be distributed through normal channels, including the Clearinghouse. The NSRDS addresses a problem in science and technology that is different from the scientific and technical information problem most commonly discussed. The NSRDS has no relation to the problems of document flow in science and technology, except to the extent that research and development will be made more efficient by the NSRDS, and therefore the amount of duplicative research and thereby duplicative documentation may be less. The NSF has no special relation to the NSRDS, although NSF endorsed the idea of the NSRDS when it was presented to COSATI.

4. A PSAC report of 1958 called for a unified, efficient and comprehensive scientific information service with NSF playing a coordinating role. In a January 1959 letter, and in Executive Order 10807 of March 1959, the President asked NSF to assume responsibility for a Federal coordinated plan. Does the transfer of coordinating responsibility to OST in 1964 and the present OST leadership reflect inability of NSF to carry out its assignment?

4. As pointed out in Dr. Hornig's testimony before your committee:

In the mid-1950's the rapidly expanding research and development activities of the many Federal agencies and the growing potential of science and technology to contribute to the Government's programs and policies gave rise to increasing concern over the lack of central consideration of the many ways in which science and technology interact within the governmental structure. It was finally recognized that a major organizational innovation was required, and that the function of central coordination and policy formulation for research and development could be carried out only at the highest level of Government—in the Office of the President. It was further recognized that Presidential leadership for this purpose required special staff support.

Also from Dr. Hornig's testimony:

In recognition that developing science policies affecting several agencies, and evaluating agency programs, can only be performed at a higher level. Reorganization Plan No. 2 was based on a transfer of two functions from the National Science Foundation to the Office of Science and Technology.

The present OST leadership in the field of scientific information is only one of the areas in science and technology in which the formulation of overall Federal plans and evaluation of agency programs is being carried out within the Executive Office of the President.

5. Further supplementing your statement, could you please describe in greater depth the role of the Science Information Service of the Foundation? Do you see changes in this role in the future?

5. The role of the Science Information Service within the National Science Foundation is more properly a matter for comment by the Director of NSF. As indicated in my testimony, however, a special task group from COSATI is devoting considerable attention to the creation of a permanent Federal mechanism for insuring the effective, efficient management of the Federal information network, and insuring its relation to the non-Government parts of the national information network. The National Science Foundation would be seriously considered as a part of the mechanism for insuring the development of an effective and efficient national information network, perhaps in an analogous way to the manner in which it assists OST in the development of national policies for support of basic research in the sciences.

6. Details of a national network of information centers was first proposed by the Crawford report to FCST in May 1962. A similar concept was proposed by Senator Hubert Humphrey. What has been the disposition of those proposals and how are present COSATI concepts related to the Crawford plan?

6. Plans for national networks of information systems or for centralized national information centers have been proposed by a number of individuals. The major plans have been critically analyzed by the COSATI task group on national system(s) and the System Development Corp. The present task group concept for a national network of information systems, with a centralized mechanism for

coordination and guidance, is a logical outgrowth of the excellent proposals put forth in the past. The gaining, over the past few years, of better understanding of the existing national complex of information services, and the specific opportunities for improving its operation have enabled the COSATI task group to select from the previous plans those parts which appear, in the light of today's evidence, to be valuable and permanent.

7. It has been suggested that NSF should have a more important function in COSATI than its other members because it does perform basic research and education functions from which information transfer becomes important. As Chairman of COSATI, what is your view?

7. The National Science Foundation has on occasion sponsored special studies of a broad character, in response both to its own evaluation of national needs and to suggestions by COSATI. NSF is a logical candidate for sponsoring and administering such programs because of its position as an agency which does not operate a specific information service, and because of its broad, permissive legislative authority. It is likely that in the future NSF will be asked to continue to fund special projects of a broad, interagency interest. A number of other agencies represented on COSATI also support a substantial amount of basic and applied research in the information sciences, and education and training activities. The proportion of total Federal R. & D. in information sciences supported by NSF is about 8 percent.

8. With respect to the Science Information Exchange operated by the Smithsonian Institution:

(a) Do the other Federal agencies coordinate adequately with SIE?

8. (a) The coordination of Federal agencies with the Science Information Exchange is improving steadily. Remaining problems, as they are identified, are studied and aggressive attempts are made to resolve the problems.

(b) Are SIE's services duplicated by the Clearinghouse in the Bureau of Standards, or by COSATI, or FCST or OST?

(b) SIE services are not duplicated by the Clearinghouse. COSATI, FCST or OST.

(c) What official position has OST or FCST taken regarding the need for and performance of SIE?

(c) Both OST and the Federal Council have endorsed the desirability of a central registry of federally sponsored research projects, and specifically the Science Information Exchange. SIE is becoming increasingly helpful as its registry of research projects undertaken within the Federal laboratories and sponsored by the Federal Government in outside organizations becomes more complete. SIE's files are especially complete in the life sciences area. This is partly due to the longer experience of SIE in the area, and also partly due to the fact that research projects in the life sciences are more usually carried out by an individual investigator or two, which makes the projects easier to classify and record.

The adequacy of the response of SIE to the needs of its users is the subject of a current study being carried out by the Battelle Memorial Institute under contract with the NSF. It is our expectation that this study will allow valuable insights into measures which are being taken to increase the effectiveness of SIE's performance.

(*d*) *With the development of new project reporting forms by DOD and NASA and the strengthening of cooperative relationships between these agencies, including ILSE, what do you believe is the outlook for making SIE a complete central repository of information on ongoing Federal projects in science and technology, including those in Federal laboratories?*

(*d*) The development of new research project reporting forms by DOD and NASA and the strengthening of cooperative relations between these agencies will contribute to the effective management of the agency research and development programs. The Federal Aviation Agency also intends to make use of the DOD–NASA research project report form. As agency reporting of research projects becomes more complete and more easily processable on modern data processing equipment, it also becomes easier for a central research project registery to obtain a complete file of research projects.

(*e*) *Would it be desirable to relieve NSF of fiscal and managerial responsibility for SIE? Should it perhaps be the responsibility of COSATI with an annual assessment made to the separate agencies?*

(*e*) The National Science Foundation was asked to take the managerial and fiscal responsibility for SIE in 1964 as an outgrowth of the continuing difficulties experienced by SIE in obtaining consistent, constructive support for its operations from its interagency governing board. It was decided (and events have confirmed the wisdom of this decision) that single-agency funding would be better managerial practice, and would contribute to a more effective SIE. To relieve NSF of this responsibility and place it on an interagency advisory committee, such as COSATI, would appear inadvisable.

9. What is being done to improve the techniques for the dissemination of scientific information, and our understanding of the actual dynamics of the communication process?

9. A number of research projects are being funded by Federal agencies, especially the National Science Foundation, and by non-government groups to improve techniques for communication of scientific information. These projects range all the way from an individual investigator working on linguistics to large organizations developing computer-based information systems serving an entire scientific discipline. It is expected that there will be increased needs for Federal support of prototype experiments involving real users and real information in real time, and that the data from these large-scale experiments will be useful in the developing plans for a national network of information systems.

10. How does a science teacher from a small undergraduate liberal arts college go about applying for Federal support of specific research and educational projects?

(*a*) *Is there a central organization in Washington currently available to disseminate the names and locations of Federal agencies upon request of these teachers, or must they search for support by coming to Washington themselves?*

(*b*) *Do you believe regional centers should be established to provide this information?*

(*c*) *Or should a Federal Government representative visit individual colleges annually to give current information to science teachers and to identify projects which would be worthy of Federal support?*

10. A science teacher at a small undergraduate liberal arts college should, in my opinion, first go to his college library to obtain information on programs for Federal support of specific research and educational projects. Federal agencies supporting research prepare many brochures detailing the procedures required for applying for Federal support, and describing the areas of study covered by the several programs. I do not believe regional centers are necessary or desirable, nor do I think Federal Government representatives should make a specific visit to colleges to provide information which can be readily obtained from college libraries.

Response by Dr. Thomas F. Bates, Assistant and Science Adviser to the Secretary of the Interior, to Questions of the Subcommittee on Science, Research, and Development

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1. The bar diagram (fig. 2) which you presented to the committee on July 28 shows total research expenditures of the Department in fiscal 1965 at a level of about $122 million, of which a little over $20 million was by three water resource agencies—reclamation, saline water, and water resources research. Yet budgetwise, water conservation and development is the Department's largest activity. What is the explanation for this seeming imbalance?*

1. The bar diagram referred to does not accurately represent water resources expenditures of the Department, because of the large amount of research in this area done in the U.S. Geological Survey.

The Department of the Interior estimate for water resources research activities programed for fiscal year 1966 is approximately $58 million—about 47 percent of the Department's total research effort. Eight Interior agencies carry on research in 38 of the 45 water research subject subcategories defined in the fiscal year 1966 water resources research program report of the Federal Council for Science and Technology.

Interior's water research activities for fiscal year 1966 are 48 percent greater than in fiscal year 1965 ($39 million), and 93 percent greater than in fiscal year 1964 ($30 million). The increase in 1966 over 1965 is largely in the program of the Office of Saline Water. The Department contemplates continuous program adjustment to maintain its research activities responsive to the needs for dealing with new and more complex water resources problems.

I have attached a tabulation of the water resources research fiscal year 1966 program estimates of the Interior agencies.

2. What is the nature and extent of Interior's program of research in river basin hydrology? Is this an appropriate field for participation by the National Science Foundation?

2. Research in river basin hydrology (as distinguished from construction, development, and management of waterworks) is largely in the province of the Geological Survey. The first phase of water appraisal work includes stream measurements, ground water exploration, and water quality evaluation which defines the characteristics of the water resources in the basin. Further investigation of the basins are needed in most cases to determine the interrelationships between recharge, movement, losses, uses, and changes which may be brought about by alterations in the natural system or by modifications induced by man's activities.

Many scientific and engineering disciplines may be called upon in conducting research on these factors. For example, one of the illumi-

* See p. 602, vol. I.

nating approaches developed by the Geological Survey, involves the use of an advanced analog model in which the interrelations of precipitation, ground water storage, surface runoff, and base flow are modeled electrically.

The National Science Foundation could assist materially in this area by supporting a larger amount of academic research on the natural processes operating in watersheds. Such information is basic to river basin development planning.

3. The recent National Academy of Sciences report on the science of geography recommended additional support for several fields of geography and the creation of two institutes of geographic research with an annual combined budget of about $900,000. Since the Department of the Interior has a geographic program, what should be the relation of the Department and the Foundation in acting upon the NAS recommendations: Should such centers be funded by the Foundation, or the Department, or by non-Government sources? What relevant discussions have you had with the Foundation?

3. The Department of the Interior is a natural center for new research on geography just as it was a natural home for the Geological Survey nearly 100 years ago. The sciences of the crust of the earth have always been basic, but an onrush of man-environment problems in very recent years has resulted in an urgent need now to reexamine and intensify our research in the uses of space and particularly in the interrelations or "systems" phases of man's various natural resource uses.

One of Secretary Udall's many public statements on the new significance of space is in his pamphlet "The Race for Inner Space," page 21:

> * * * the United States has the opportunity to set an example of how to plan the best relationship of human beings to their environment. We should give solemn attention to the matter of developing the optimum man-land ratio—the ratio which would result not only in the highest and best use of the land, but the highest and best development of free men.

The matter of funding institutes of geographic research will, of course, require considerable study particularly since the need is so great and the area of concern so broad that several types of operations are probably necessary. The Foundation might consider a national center for geographic research to strengthen the fundamental research side of the picture, whereas consideration can be given in Interior to organization and funding required for short- and long-range applied research to provide the background for necessary action programs.

These matters have not been discussed with the Foundation.

4. Your testimony also mentioned studies of outdoor recreation. Do you consider this to be scientific research, or is it merely a matter park statistics and administration?

4. Although the effort in outdoor recreation research is small at the present time, there is a need for research on outdoor recreation phenomena which goes well beyond collection of statistics and effecting administration. Specific research in outdoor recreation will concern human resources and social aspects as well as physical resources. Some of the goals are:

(1) Determination of needs for additional outdoor recreation professional personnel.

(2) Determination of needs and preferences of the users of outdoor recreation.

(3) Determination of the effects of outdoor recreation on human behavioral patterns.

(4) Assessment of future outdoor recreation resources and facility needs nationally with projections of requirements to years 1980, 2000, and 2020. Included also will be research on characteristics of recreation resources, their management, and optimum uses.

5. Can you elaborate a little on your reference to the ecological conflict in the Florida Everglades—that is, the increasing use of the canals by the human population and its effect on the national flora and fauna, from palmettos to alligators. What is the nature of the NSF program you mentioned? Does it need to be modified, expanded?

5. The southern portion of the peninsula of Florida receives most of its fresh water by surface drainage from the Lake Okeechobee region. This flow of fresh water southward and outward toward the coasts inhibits the penetration of salt water into the peninsula. Nevertheless, as the coastline is approached changes of salinity in the inland waters do take place and do much to control the plant and wildlife balances in the area. The various types of grasses, the distribution of mahogany, cyprus, and mixed hardwood hammocks, the areas of mangrove swamps, the inland penetration of marine life in the rivers, and the presence and quantity of numerous species of birds, animals, and fish all relate to balances established by the salt-fresh water relationships. These sensitive ecological situations have not been either understood or appreciated, and consequently, until the past few years, little thought was given to them when needs for the human population of the area were considered. As a result canals dug for irrigation and flood control and major roadways have now disrupted much of the southward flow of fresh water; salt water penetration into the Everglades is increasing each year; and the natural balances are being destroyed to the detriment of plants, wildlife, and humans alike.

The NSF program referred to is in the form of a grant to the Pennsylvania State University for research on "Characteristics of Modern Organic Sediments." It involves a study of past and present ecological situations in the Everglades as related to the formation and occurrence of peat in the area. Although the major objectives of the project are geological, the data being obtained are pertinent and necessary for ecological studies also. NSF has supported the study for approximately 5 years, and the grant was recently renewed with $63,400 being allocated for 2 years. The proposal for renewal requested support in the amount of $68,000 for 1 year, and, consequently, the funds supplied will support approximately one-half of the recommended research.

6. Among the technical departments, Interior is one that does not appear to have an extensive basic research program in colleges and universities. How do you obtain the basic research needed for Interior's scientific activities? Should the Foundation support basic research related to your interests? Have scientists of Interior discussed with the NSF staff or its Board or Director this possibility? With what results?

6. Interior has, up to the present, satisfied most of its basic research needs by inhouse effort. In 1965, the effort amounted to $37 million out of a $115 million R. & D. budget. The need for more basic research support from universities has become evident, however, and contract

and grant programs have been initiated in a number of the Bureaus. The new program of the Office of Water Resources Research, involving grants to universities in the 50 States and Puerto Rico, represents a major step forward in Interior-university relationships.

The National Science Foundation, particularly through its earth sciences and biological programs, does support considerable basic research related to the interests of the Department; but this is simply due to the great breadth of interest involved rather than as a result of planning. There have not been formal discussions between Interior and the Director of NSF on NSF support of basic science of interest to Interior.

Through interest in common programs, such as in geology, oceanography, and atmospheric sciences, specific cooperation has been arranged between Interior programs and NSF-supported research. This could be expanded with real benefit to Interior research needs, with probable benefit to NSF interests, and certainly no loss of NSF responsibilities.

7. Secretary Udall's letter of November 12, 1964, which you introduced at the hearing, outlines research programs in water resources and land resources, among others. In this connection, what is the Denver laboratory of Bureau of Reclamation, financed—from research in the following:

(a) Dam design: Is this considered a science, or is it strictly engineering? How are the studies on this subject, as performed at the Denver Laboratory of Bureau of Reclamation, financed—from research funds, from construction funds, or what?

7. (*a*) Dam design, as practiced in the Bureau of Reclamation, is considered to be a science. Research studies on dam design performed in the Bureau's Denver laboratories are financed from nonreimbursable research funds. Specific dam design is financed with construction funds which are reimbursable to the extent that the total project is reimbursable.

(b) Family farm policy: Are the acreage limitation provisions of reclamation law outmoded by corporate farming? What sort of study, scientific or social, is underway or contemplated regarding the applicability today of the legal limitation of 160 acres for which any individual may receive reclamation project water?

(*b*) The large number of privately owned family farms being successfully operated on reclamation projects today, in compliance with the acreage limitations of reclamation law, indicates that these provisions are not outmoded by corporate farming.

There has been a thorough acreage limitation policy study which the Committee on Interior and Insular Affairs of the Senate by resolution requested the Secretary of the Interior to initiate. The committee requested a report setting forth the history of the laws, regulations, and policies of the Federal Government respecting limitations on the delivery of water from Federal projects to lands for irrigation purposes in excess of a specified or limited number of acres in individual or family ownership and other details on the subject. The Secretary was further requested to include in his report statements of the advantages and disadvantages of the acreage limitation policy as presently in effect, and his recommendation for desirable change or modification.

In response to the request contained in the resolution, the Secretary, on June 30, 1964, transmitted to the committee his study entitled "Acreage Limitation Policy." The report has been published as committee print, 88th Congress, 2d session.

(*c*) *Electric power transmission: How much of the current research in extra-high-voltage, long-distance power transmission is being done by Federal agencies? How much by private enterprise? How much by foreign countries?*

(*c*) Research and development by the major power marketing agencies (Bonneville Power Administration and Bureau of Reclamation) amounted to nearly $900,000 for fiscal year 1965 in the field of electric power transmission facilities. The majority of these moneys were spent in the extra-high-voltage field for both alternating current and direct current programs. No report is available on the R. & D. activities of the Tennessee Valley Authority, which is building extra-high-voltage transmission lines.

From an Edison Electric Institute Bulletin of July 1964 the following statistics were given as to research and development work for calendar year 1963:

138 electric utilities R. & D. on 1,831 projects	$53, 180, 000
Edison Energy Institute funds on 32 projects	757, 578
Manufacturers' effort in the power transmission field including generation, transmission, and distribution	97, 560, 000
Total	151, 497, 578

As can be seen, the Interior effort is only a very small part of the private utility and industry segment of research and development of electric power facilities. In addition, the Edison Electric Institute Bulletin does not include that research being conducted by municipalities, public utility districts, and cooperatives, such as work being done by the city of Los Angeles in connection with building an extra-high-voltage direct current transmission lines as one segment of the Pacific Northwest-Pacific Southwest intertie.

No information is available on research in this field by foreign countries, but it could possibly be of the same magnitude or larger than the U.S. effort.

(*d*) *To what extent, if any, are these three subjects proper fields for inquiry by NSF?*

(*d*) Since proper dam design relates directly to basic research in the area of rock mechanics and the mathematics of stress theory, basic research supported by the National Science Foundation in these areas is very important. There is less relationship of NSF areas of concern to the matters of family farm policy and electric power transmission.

8. *How useful has the Department found the Science Information Exchange? Are any changes needed to make it more useful for your purposes?*

8. The Department has found Science Information Exchange highly useful in furnishing information necessary for research management and for advanced planning. All Interior Research projects have been placed in SIE since about January 1964. The following general uses have been made of SIE services:

(1) Cross-communication on research within the Department.

(2) Review of projects already in effect, in Government or university research programs in various fields such as saline water conversion or water research before placing grants or contracts.

(3) Review of all research in a field of science or geographic area (for example, in ecology or in the Arctic).

During the period of 1 year following January 1964, Interior made 165 requests of SIE, totaling 221 different questions. This resulted in the furnishing of over 20,000 notices of research projects to scientists and research administrators.

The SIE under contract to Interior's Office of Water Resources Research has prepared a catalog on current research in water resources, and is preparing a thesaurus of terms for water research.

Although SIE is working to improve input to the system, the services would be more useful if there was more complete coverage of all Government-supported research projects.

9. In respect to communication with other scientific and technical agencies, you testified that informal relationships are best, but that they require a base of formal relations—and that Interior, at least, does not have adequate formal ties to give informal talks significance. Why is this so? Does it imply any special role for the Information Exchange or for NSF?

9. The absence of enough formal ties between NSF and Interior is the direct result, in my opinion, of the insufficiency of funds being allocated to the study and use of our natural resources. The appropriate sections in NSF have only enough funds to support the most basic research proposals. There is little or no chance for NSF to satisfy enough of the basic research needs and have money left over to move far enough toward more mission-oriented research. Similarly, Interior should do more long-range basic research but cannot when there is not enough money to conduct the "short-range" research necessary to accomplish the "missions." Consequently, it appears that the view has been taken in the past that there is not much point in having, for example, an NSF-Interior Committee working on the problem of closing the gaps in research between the two agencies if there are no funds with which to build the bridges.

This situation will exist as long as funds remain scarce and NSF distributes research funds largely on the basis of proposals submitted (see answer to question 12). Nevertheless, I would agree that another approach can be taken; namely, that of setting up formal NSF-Interior committees with the object of evaluating the problems and initiating action leading hopefully to procurement of funds. I believe the present climate in the executive branch and the Congress makes such an operation more realistic now than in past years.

As to implications re a special role for NSF, I would again refer you to the comments in answer to question 12 (and in my testimony) regarding management, not of research, but of research activity within as well as between fields of science and engineering.

10. As a mineralogist, what can you tell us about the prospects of recovering minerals—especially precious minerals—from the sea? Is there need for scientific research in this field? By what agency or agencies?

10. There are reasons for optimism concerning recovery of minerals from the Continental Shelves and ocean bottom. In certain places minerals from the continental masses have been washed into the ocean and have been redeposited in sufficient quantities to warrant exploitation. Diamonds are currently being recovered from such an underwater deposit off the African coast. Norton Sound in Alaska is being examined to determine the possibility of gold recovery. In addition, numerous bottom samples have shown the presence of base metal compounds in significant quantities.

Information concerning the amounts and location of possible undersea mineral deposits is both scanty and sporadic. There is, therefore, a major need for a continuing systematic sampling program of ocean-bottom materials as a part of the national oceanographic effort. Such a program could best be undertaken by the Geological Survey.

There is also the parallel need to develop the technology that will permit commercial extraction and beneficiation of these resources, and this lies within the mission of the Bureau of Mines.

11. Since the Mohole project is a great geological experiment, what has been the role of your Department vis-a-vis the Foundation in the project?

11. Personnel of the Geological Survey have served on committees and task forces assembled for evaluating the Mohole project, investigating its feasibility, and selecting the drilling site.

Geological Survey personnel have participated extensively in some of the experiments under the Mohole project, and provided laboratory services in studies of samples necessary to the project.

12. From your standpoint as a senior scientist in Federal service, what limitations, if any, affect the role of the Foundation as a balance wheel for Federal support to different fields of basic research?

12. The limitations, in my view, are lack of funds, lack of communications, and lack of flexibility in fund management.

More funding is essential because to achieve proper balance there must be enough money to support adequately a very large number of important areas of science and engineering, and enough to permit shifting of funds from one area to another as the needs change without causing major disruptions in the ongoing, long-range programs.

Lack of adequate communication makes it impossible to determine where funds are most badly needed. As I tried to point out in my statement, closer formal ties between NSF and "mission" agencies (for example, in the form of working committees charged with evaluating gaps in science coverage in areas of mutual interest) would permit more adequate evaluation as to how the "balance wheel" should operate.

Lack of flexibility in the management and distribution of funds prevents NSF from meeting its total responsibility. As long as funding of research within a given area of science or engineering is dependent primarily upon the number and dollar amounts of proposals received and upon the judgment of "peers", a balance will not be achieved. The present system is very effective and should continue but it should not keep the NSF from making its own assessments as to total needs in science (including new areas, "unpopular" areas, etc.) and then encouraging activity irrespective of proposal demand or peer judgment.

13. In the light of your experience with computers at Penn State University, what is your opinion of the current NSF program of replacing several hundred computers which they had acquired for the universities in the late 1950's? Do you believe rental of the computers would be more economical?

13. NSF's program which provides funds for replacement of earlier model computers is an essential one. Computer science is a rapidly developing area of technology both with respect to hardware and application. As in any such area instrumentation becomes rapidly outmoded. Because the progress of American science and technology is inexorably linked to progress in computer development and usage, we must move ahead as fast as this particular branch of our science will permit. Universities, being in the forefront of science, must be equipped with the most modern computers available. Those universities which have been in the computer business for the longest time are the very ones which can use the latest machines to the best advantage. Thus continuous updating is a necessity which can be met only if much more Federal help is available. NSF's program in this area should be greatly expanded.

It is difficult to generalize as to computer rental versus purchase. At my university, Pennsylvania State, we have found it convenient and economical to rent a large part of our computer system but to purchase some of the components that will not become outmoded as rapidly as others. In general, however, because of the rapid developments mentioned above, I believe rental may be more economical in universities large enough to have a computer science faculty and strong graduate research programs. As major changes in computer hardware become less frequent, purchase will probably become more economical than rental.

14. As an employer of varied scientific and technological skills, has Interior observed any problems of early obsolescence of these personnel because of rapid advances in science and technology? If so, what are your views about the role of NSF in devising and sponsoring professional retraining?

14. Obsolescence of skills is a problem in almost all types of work, but scientific and technologic skills can be maintained, and even enhanced, by involvement in or close association with an active and varied research program. Bureaus like the Geological Survey, which include university people as active researchers in the operating program, have less difficult with the obsolescence of personal skills than Bureaus with missions that do not relate them as closely to university personnel and programs.

Professional retraining is essential in many of the Department's activities and the Science Foundation with its experience in science education, should be able to provide guidance and leadership in devising the basic patterns that might then be adapted by the individual agencies to their specific needs.

The Foundation could also do much to alleviate the individual Government agency problems of limited time and funds by supporting the establishment of professional refresher training courses at selected educational institutions through the use of NSF grants.

15. What future emphasis do you think the Foundation should give to engineering research and education in comparison with basic scientific research and education?

15. Since support of both science and engineering is the responsibility of NSF, the two areas should be of equal concern to the Foundation in planning designed to meet national needs. The emphasis to be placed on one area versus the other will change from time to time depending upon the needs and the amount of money made available by other funding agencies in the public and private sectors. To determine how its funds should be divided at any given time, the Foundation must make realistic management-type decisions as to current needs and how its money can best be spent to supplement other funds going into science and engineering endeavors. It should retain its position as the chief Federal source of funds for basic research and leave short-term applied research to other agencies. However, it should assume much more responsibility than has been possible in the past for evaluating and possibly funding the large amount of engineering research that falls between these two extremes and has, therefore, been left out in the cold. The NSF, however, will not be able to take this approach if its funds are not increased very appreciably. At the same time, the mission agencies (particularly those operating in the area of natural resources) will not be able to do their part in closing the gap without similar augmentation of funds.

16. Has the Department had occasion to indicate to the Foundation the desirability of creating new centers of academic excellence in sciences important to your interests? Would such a request be consistent with your understanding of the purposes of the Foundation?

16. The Department has not taken initiative in proposing to the Foundation that new centers of excellence be established. This should be explored and in my opinion this would be consistent with the purposes of NSF. There would have to be a common ground of responsibility; for example, support of a basic science effort in a resources field of interest to Interior.

Again, through cooperative planning on programs in which NSF, Interior, and other agencies have an interest, there has been an Interior contribution to NSF creation of centers of excellence. Examples are the National Center for Atmospheric Research and numerous university oceanographic research centers.

17. The point has been brought during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. Specifically, what guidelines or criteria has your Department established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of Interior's jurisdiction and, therefore, should, or should not, be supported by the agency? If written criteria have been established, please submit a copy thereof to the committee.

17. The principal criterion for determining whether or not a project is supported by Interior is the subject or purpose of the proposal. Interior's research is mission oriented and even basic research sponsored or conducted by Interior will contribute knowledge to a field of science in our subject areas. Usually there is little difficulty in reaching a decision on whether or not the research is related to Interior's mission.

By contrast the NSF sometimes refers research proposals to Interior for consideration of support because they are of an applied nature in a field of Interior's responsibility.

Criteria for support and guides for submission of proposals have been established by agencies in the Department which support extensive extramural research. These are the Office of Saline Water, Office of Coal Research, Office of Water Resources Research, Federal Aid to Fish and Wildlife and Federal Aid to Commercial Fisheries. Copies of regulations and guidelines materials from these programs can be found in the committee files.

Response by Dr. Arnold B. Grobman, Executive Director, Biological Sciences Curriculum Study, University of Colorado, to Questions of the Subcommittee on Science, Research, and Development

1. In 1959 a report of the President's Science Advisory Committee entitled "Education for the Age of Science" recommended concerning course content that "A mechanism must be found to provide continuous review and revision." Based on your experience with the biological sciences curriculum study, do you think a one-shot effort is sufficient, or should a capability be maintained to periodically upgrade curriculum materials in science courses?

1. I think it essential that a mechanism be found to provide for continuous review and revision of course content. The obvious reasons are that our knowledge of content, and methods of presenting content, are changing daily and the best we know should be brought to bear on education in our schools. There is also a negative effect that could result from a "one shot" approach. If a course were revised by a group of acknowledged experts, and not subject to recision, the resulting new course might itself become a prestige but static course through which the deadly hand of tradition would adversely affect the lively growth of education. I believe that a capability should be maintained to continuously upgrade curriculum materials, especially in science courses, for a new orthodoxy could be just as undesirable as an old orthodoxy.

The frequency of revision would depend on the nature of the particular course and each project should be judged independently on its own merits and goals. For example, a manual on the use of an electron microscope could remain essentially unchanged until such time as the electron microscope itself underwent comprehensive modification. A project of this type would not require the establishment of a permanent curriculum development facility. In contrast, however, a total program of a broad nature in the improvement of education, such as that of the biological sciences curriculum study, should operate continuously in order to keep its materials up to date in content and up to date in reflecting the pedagogical aspects of the program as more knowledge is gained on how students best learn the specific subject.

2. One argument against a continuing revision project is that the development of a permanent group of textbook writers might lead to sterility of thought and isolation from their fields, or to undue influence by one group of men on a particular curriculum. How much of a danger do you consider this?

2. I think there is a potential danger in having a permanent group of textbook writers continuously responsible for the content of one particular course. In the case of the BSCS, I think we were able to effectively avoid this danger by having virtually complete rotation

of the personnel of our major policy committee. With one-third of the committee rotating each year, there has been effected an almost complete rotation every 3 years. Large numbers of people have contributed to the program for varying lengths of time and there are no permanent appointments to the BSCS. The "one group of men" involved in the BSCS consists, to a very large extent, of a significant proportion of the American biologists interested in, and able to devote time to, curricular design. Over 2,000 persons have been intimately involved in the work. In other words, the answer to this question depends primarily on the organization of the curriculum study group. If there are provisions for the substantial rotation of personnel and for the participation of significant numbers of specialists, I see no particular danger in having one group responsible for a course development program and there are a great many advantages. If there are not provisions, however, for substantial rotation of personnel and utilization of many persons, I feel the group should simply complete a "one shot" job and then a new group should be organized as revision time approaches.

If the criteria listed above are not met, there could be a danger that control of curriculums could fall into the hands of a small group of individuals who could strongly influence education throughout the United States. This would, of course, be deplorable. In terms of the BSCS, however, just the reverse has occurred. For the past 30 years, the textbooks used most widely in the teaching of biology were written by the same small group of individuals who did not have access to substantial counsel from professional biologists and high school biology teachers. Authors of those texts prepared manuscripts following the recommendations of publishing houses based upon sales records. A continuously operating curriculum study, with a rotation of personnel involving professionals from all areas of education concerned with the teaching of science, is a safeguard against the danger that any one group of individuals would introduce sterility of thought or produce orthodoxy as has been the case in biology prior to 1960. I do not think there is any danger that properly organized and operated curriculum studies would produce this kind of control but, to the contrary, such curriculum studies would tend to prevent the sterility of thought that we have been faced with for the past generation.

3. Referring to your memorandum of June 11, 1965, addressed to the BSCS executive committee, are you aware of any critical analyses of like nature on the National Science Foundation's funding operations and the fiscal management of its programs?

3. I know of no document analogous to the memorandum of June 11 to which reference is made. Informal conversations with other NSF grantees, however, has led me to believe that the criticisms in the memorandum are representative and would be affirmed by the directors of many NSF-supported projects.

4. You testified on July 29 that alternative sources of financial support for BSCS, or other curriculum study groups, might be private foundations or the U.S. Office of Education.

(a) Considering the growing authority and funding of the Office of Education and its close contact with the educational system, should the Foundation's interests in curriculum revision for scientific subjects be shifted to that Office?

(b) Do you think that fiscal control by the Office of Education would be free of the management difficulties ascribed to NSF in part V of your statement—particularly "undue policy control"?

(c) How much policy control would be exercised by private foundations?

4. (*a*) My general feeling is that the support of curriculum development and revision has been so successful in the sciences that it should be extended across the board to all areas. It becomes proper, therefore, to ask whether this function should be removed from the Foundation and given to a broader gaged agency like the Office of Education. My general reaction is that this should be done, but it should be done cautiously because the Office of Education has not yet established, in my view, an authority and prestige comparable to that of the Foundation in the area of curriculum revision and design. With the new leadership and increased funding of the Office, it is likely that this might come to pass. Perhaps the way to proceed with caution would be for the support of projects to be moved from one agency to the other in a stepwise fashion. For example, the Foundation might continue to fully support the design and revision of course content projects except, initially, that the related aspects dealing with the preparation of teachers be funded through the Office of Education. With successful experience in this division of funding, perhaps the matter of studies of instructional media and pedagogical procedures could then be transferred to the Office from the Foundation. A last step would be the matter of the transfer of the funding of the design of the course content itself. Such a three-step sliding procedure in transferring the responsibility for funding might provide both agencies an opportunity to adjust to new requirements and might provide a period of testing during which an evaluation could be made of whether the Office of Education could assume the responsibility in an adequate way.

(*b*) I have no direct experience to indicate that fiscal control by the Office of Education would be more or less restrictive than that of the NSF but I have been advised by colleagues that it is now more restrictive. If my information is correct and this situation continues to prevail, a transfer of support from the NSF to the Office of Education would be undesirable because many good scholars and scientists simply are not willing to work on projects burdened with restrictions they feel are unwarranted.

(*c*) Our experience with the Rockefeller Foundation has been close to ideal. General terms of a grant were agreed upon in the first instance and no important contacts between the BSCS and the Foundation were necessary until the submission of a final report. Our Rockefeller grants have been the most permissive we have received and, for this reason, the most valuable to us. Our experience with Asia Foundation grants was similar. The general reply, then, to the question is that BSCS's experience with grants from private foundations has involved virtually no policy control by the foundations. I understand from other colleagues, however, that this is not always the case with grants from the Ford Foundation.

5. Are the principles and methods of curriculum improvement outlined in your statement applicable also to the social sciences? If so,

should social sciences curriculum studies be supported by NSF? By the O. of E.?

5. The general principles of curriculum improvement are fairly simple. What is required is the bringing together in meaningful cooperation the scholars in a field and the teachers of that field in an environment conducive to collaborative effort. The second step is widespread and honest evaluation of the materials in live classroom situations, repeated as appears necessary, with the final production of classroom materials dependent on such rigorous testing. Supplementary materials, of course, need to be developed along the way. This general procedure should be equally applicable to the social sciences as to the sciences. It is extremely desirable that substantial support be given to the social sciences and humanities for curriculum improvement. I doubt if the NSF would be the appropriate home for the funding of social science curriculum improvement because the personnel of the Foundation is now drawn almost exclusively from the sciences. With its growing authority and prestige, the Office of Education might become an appropriate place for such funding to be housed.

6. In your view, which is the more important mission of NSF—the promotion of scientific research or the advancement of science education?

6. Both missions are important and are interrelated. Likewise the missions of improvement of science education and the improvement of social science education are equally important and are related to each other. If the advancement of education, through curriculum improvement among other ways, could be satisfactorily housed in the Office of Education, then I think the mission of the NSF might be profitably devoted to promotion of research in the basic sciences, recognizing that certain applied aspects are already being substantially funded by the National Institutes of Health, the Atomic Energy Commission, the National Aeronautics and Space Administration, and other Federal agencies.

7. Granted that the upgrading of education in the sciences is desirable and that the curriculum revision has been successful, to what extent would it be desirable to extend curriculum revision to the course material for training technicians needed to work with scientists and engineers? For what reasons might the Foundation support curriculum research and revision for the growing number of 2-year community colleges?

7. I am not sure whether or not there is a serious problem regarding the revision of course materials for potential technicians. Perhaps a simple way to determine the advisability of such projects would be to discuss the matter with a representative group of persons who are responsible for the training and utilization of such technicians. On the other hand, I am convinced that a good deal of work needs to be done regarding curriculum research and revision for the burgeoning number of 2-year colleges and I believe that much could be done to assist these institutions in improving the caliber of their offerings.

8. We have heard it said that the college entry examinations boards have not been revised to take into account the new curriculums being devised in mathematics and the sciences, and that students who take the old-style courses may score appreciably higher on the examinations.

What has the BSCS or the Foundation done to secure recognition of these new curriculums by the entrance tests?

8. The college entrance examination board is apparently an extremely conservative body. It has a number of policies which tend to work against change in curriculums. For example, it believes (properly so) that its examinations should reflect what is taught in the schools rather than what the CEEB (or anyone else) feels should be taught. Hence it tends to "follow" curriculums rather than "lead" curriculums. This general position inhibits teachers and others from trying out new ideas because such new ideas would not be tested by the CEEB exams until they became used rather generally. In essence the CEEB exams tend to put a floor under achievement but they also tend to place a ceiling on experimentation. As far as the BSCS and the CEEB are concerned, both organizations have been in frequent (and discouraging to us) contact with each other. In the earlier days of the BSCS program, extensive tests were given to students taking BSCS courses and students taking traditional biology courses. The results, in general, were about as follows: students taking BSCS courses and students taking traditional courses did equally well on CEEB (traditional) examinations; and students taking BSCS courses did substantially better on BSCS examinations than students taking traditional biology courses. (This latter result could have been anticipated because the traditional and the BSCS courses are rather different.) Based on these results, the BSCS has insisted that CEEB has the obligation to prepare two College Entrance Board examinations in biology: one for students taking traditional courses and one for students taking BSCS courses. The CEEB response has been that a single examination is sufficient because BSCS students and non-BSCS students do equally well on the CEEB exam. The implication is that the CEEB exam measures both groups fairly. The CEEB has been unwilling to recognize that the CEEB exams do not take into account some of the important materials BSCS students are learning, over and beyond what non-BSCS students are learning.

There is very little else, to my knowledge, that can be done to convince the CEEB of the magnitude of the problem. On the other hand, the problem is going to take care of itself because, as things are now developing, the "standard" type of biology (upon which CEEB exams are based) will become more like BSCS and less like traditional biology in a very few years. It will, therefore, probably follow that the CEEB exams will be gradually altered to reflect this trend.

I do not believe the Foundation should become involved directly in this problem since the CEEB is a purely private organization. I do believe, however, that the Foundation should not fund any projects initiated by the CEEB or its parent, the Educational Testing Service, until those organizations exhibit greater responsiveness to change in their testing programs. On its part, the BSCS is seriously considering designing and marketing its own biology exam which would presumably compete with and probably replace the CEEB exam. It is most unfortunate that CEEB failed long ago to take adequate cognizance of the very great changes taking place in education through the major curriculum studies.

9. Subsequent to your testimony, the suggestion was offered that a "comparative study" be made of the various curriculum study groups

in the country, for the purpose of evaluating their course content improvement criteria, assessing publications problems and procedures, and examining instructional materials that are developed. What would be required in terms of staff personnel, time, and travel to complete such a study?

9. I understand that the Carnegie Corp. has been invited by the U.S. Commissioner of Education to conduct a study of the feasibility of making a national assessment of educational achievement. Such a study, I would assume, might cover part of the inquiry indicated in this question.

To conduct the study proposed in your question would require an alert and imaginative director, of real competence, who would report to a rather representative policy board. For each of the several disciplines, consultants would be needed to review the criteria upon which each of the curriculum study groups based its work on content improvement. Perhaps a single panel could assess publications problems and procedures since these would probably fall into a few major categories. If more than a cursory examination of the instructional material produced is envisaged, a tremendous effort would be required. However, if just a brief review is made without an attempt at depth evaluation of the developed materials, then a large staff would not be necessary. Confining the study in this way, a modest investigation should be appropriate. Such a study could be confined to the major curriculum study groups and each group should be visited by a team of about three consultants. Only a sampling of the smaller study groups would seem to be indicated and they might supply some information through questionnaires. The major study groups would seem to include: one in physics, two in chemistry, one in biology, two in mathematics, two in earth sciences, one in junior high school science, and two in elementary school science. Assuming a visit to each study of 3 days by 3 persons, plus three 3-day meetings of a policy committee of about 12 persons, and the 6-months' salary of a director (who would do this job on a leave of absence basis) and his clerical staff, the net cost might be something in the neighborhood of $60,000.

10. A supporting recommendation of the 1959 report of the President's Science Advisory Committee entitled "Education for the Age of Science" was the preparation of challenging, stimulating, and exciting textbooks and auxiliary reading materials in mathematical and scientific fields, priced so that a larger number of students will be able to build their own libraries. What does your experience with BSCS suggest about the feasibility and desirability of the Foundation sponsoring such projects?

10. Our BSCS experience does not give us specific clues to this query, but I am completely sympathetic with the suggestion that the Foundation support such projects. Teachers indicate real interest in such materials.

11. The hearings indicated that users of scientific information are not clear as to what Federal resources are available to them. Please report what use, if any, you have ever made of:

(a) The Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards.

(b) The Science Information Exchange, Smithsonian Institution.

(c) The National Referral Center for Science and Technology, Library of Congress.

(d) The Office of Scientific Information Services, National Science Foundation.

Please evaluate the usefulness of these sources and describe any problems you may have encountered.

11. In my work in administering the BSCS I have not made direct use of any of the sources listed, although I have scanned the NSF Scientific Information Services reports, which have contributed to my background knowledge. To what extent the actual writers of the BSCS materials used the items listed I do not know but I would guess that it has been rather minimal.

12. You had a parenthetic reference in your statement to "the extensive overseas activities" of BSCS. Could you briefly describe your foreign program? Should NSF assume a more active role in the support of international science projects?

12. The BSCS overseas program is very extensive and continues to grow at a very rapid rate. It is important to note that all overseas programs involving the BSCS were initiated by individuals in the various countries and not through solicitation by the BSCS itself. Biologists in many overseas countries had obtained copies of our materials and independently made the judgment that these materials could be useful in their countries. The BSCS, on its part, has taken the position that its materials should not be directly used overseas. Rather, they should be adapted to fit the flora, fauna, educational system, and social mores of the overseas country involved. To accomplish this, adaptation committees of local biologists and educators were indicated. Hence, when we received requests for direct use or permission to translate our materials, we recommended that a local adaptation committee be organized and suggested that we would be glad to cooperate with such a committee. Overseas adaptations of BSCS materials are thus produced largely by their own writers and published by their own publishing houses. In brief, this is not an export of Americana to other countries. In each case the adaptation of BSCS materials belongs to the respective country whose biologists found BSCS materials to their liking. Our recent "International News Notes" gives you some idea of the scope of our program. (A copy in committee files.) In brief summary, the following is the situation:

A group in Colombia is now preparing a second edition of a biology course designed for tropical America, in Spanish, based upon our Green Version. It is being, or has been, tested in all, or in part, in El Salvador, Guatemala, Colombia, Ecuador, and Venezuela. It has been studied by biologists in other parts of Central America and northern South America as well. The BSCS has assisted in the training of 50 Peace Corps volunteers who will be assigned to biology teaching in Colombia. In Brazil, a group of biologists has made specific adaptations and translations into Portuguese of both our Blue and Green Versions; these are now in press. In Argentina, a local adaptation team has prepared a biology course for use in temperate South America, in Spanish, based on our Green Version. This is being tested in Argentina, Peru, Chile, and Uruguay. A Portuguese-speaking American biologist, familiar with the BSCS program, spent 6 months in Brazil with the local writing team and we have been able to arrange

for BSCS writers to visit Colombia and Argentina for shorter periods. Members of the writing teams from the Latin American countries spent the summer of 1961 in Boulder working with BSCS writers and we have had a resident consultant in Central America. There has been considerable interchange of information and at least two Inter-American Conferences on the Teaching of Biology have resulted from these activities.

An adaptation team has been established in Quebec to prepare an adaption and translation of the Blue Version for use in French-speaking Canadian schools.

In Japan, an adaptation and translation of the Blue Version is underway with two BSCS writers in residence in Tokyo for part of the summer to work with the Japanese adaptation team.

In the Republic of China (Taiwan), an adaptation of the Yellow Version is being accomplished through a committee of Chinese biologists. The chairman of that committee is spending 9 months in Boulder working there on the adaptation. Also in Boulder is the chief artist of the Taiwan adaptation team.

In the Philippines, there has just been published a Philippine adaptation of the Green Version which had previously gone through an experimental edition. A well-organized adaptation team consisting of six Filipinos and one American (a BSCS writer) effected a very successful program which resulted in the first biology book ever prepared for Filipino conditions. The work has been so highly regarded that the Ford Foundation has recently financed a whole series of curriculum projects in Manila covering grades one through high school.

In Thailand, an adaptation of the Yellow Version laboratory manual has been completed and is being tried out in a number of schools. Two Thai writers spent the summer of 1961 in Boulder working with the BSCS.

An authorized adaptation and translation of the Yellow Version has been made in Russia, and several abridged and unauthorized adaptations of BSCS versions have been made in Taiwan.

In India, the BSCS (with AID support) conducted a summer institute for high school biology teachers in 1963 based upon the Yellow Version. Because of the success of the initial institute, four such institutes were conducted in 1964 and seven more institutes in 1965. Permission was given the Indians to prepare a reprint of the Yellow Version in anticipation of the establishment of a writing team to prepare a specific adaptation for use in India.

Considerable interest in the BSCS materials exists in England, and a group there publishes a BSCS British newsletter describing their activities in England. There are plans to prepare an adaptation of the Green Version. In the meantime, all three versions are sold freely in England.

In Australia, a very active adaptation team has been established with the goal of completing an adaptation of the Green Version within a 2-year period. The secretary of the team will be in the United States shortly to visit BSCS headquarters.

An active adaptation team is working in New Zealand and one of its members was recently in the United States to visit and compare procedures.

Demonstration classes of BSCS materials have been taught by experienced persons (either natives or Americans) in the Netherlands, Denmark, Italy, Mexico, Turkey, and Norway.

Conference on BSCS materials have been held in many countries, including Nigeria, Ceylon, Kenya, Singapore, Hong Kong, France, Switzerland, and elsewhere.

Serious overseas visitors to BSCS headquarters average about 1 a week. Most visits are for several days' duration, and the visitors are genuinely interested in studying the process of curriculum revision and seeing the results of our work.

BSCS writers or staff members have visited all of the countries indicated above as well as Peru, Nicaragua, Costa Rica, and Honduras and have worked within the framework of OECD and UNESCO.

Many overseas publishing companies are anxious to have rights to translate and publish our versions, pamphlets, laboratory blocks, and other materials. Most of these offers are being declined because of our feeling that the material should be specifically adapted before being used in overseas nations. The results of this position seem to be that the participating countries are improving their education in biology; they are doing it largely by their own efforts with cooperation and assistance by Americans; there is resulting a large number of person-to-person contacts between biologists in the States and overseas; and leaders in the overseas countries are looking to the United States for contacts in their work in improving biological education.

It seems to me that this is possibly one of the least expensive and most successful international programs in which the United States is engaged. Most of our work has been done on a shoestring budget with small sums of money being made available by the Rockefeller Foundation, Asia Foundation, and, indirectly, AID through the NSF. More substantial support for this activity should certainly be provided. I think there is no question that great benefits would accrue to both the United States and to the participating nations through increased NSF support of international science projects such as that described above.

13. What contacts has the BSCS had with biostudy groups of the National Academy of Sciences?

13. A study group was set up by the National Academy of Sciences National Research Council to prepare a source book for high school teachers of biology. This "Source Book of Laboratory and Field Studies in Biology," produced at Michigan State University in 1957 under the aegis of the NAS–NRC, could be considered the precursor of the BSCS. As the BSCS developed later, it borrowed heavily from the "Source" book and took considerable advantage of the work of the National Research Council. As another example, in selecting persons to be invited to the BSCS writing teams, the files in Washington of the NRC were carefully reviewed by the BSCS. Reports by earlier NAS–NRC study groups, especially those of the late 1940's, were read carefully by BSCS writers. I do not recall any substantial contacts between the NAS–NRC and the BSCS during the last 3 or 4 years.

14. What evidence have you seen that the textbook publishers are more likely to do a better job upgrading and revising curriculum materials developed through NSF funding than they did before NSF

undertook support of such programs? Can the Federal Government withdraw and still expect the quality of texts to be maintained at the desired level?

14. I have no evidence that yet indicates the textbooks publishers are likely by themselves to upgrade and revise their books without outside support. If left solely to their own devices, I am afraid that publishers would respond to the nonacademic marketplace control and gradually reduce the contents of their books to low standards. I am convinced that the withdrawal of support by the Federal Government would adversely affect the maintenance of the quality of our books at a desired level. The structure of the textbook industry is simply not conducive to the production of rigorous and modern curriculum materials for the public schools. On the other hand, Federal support of study groups in no way precludes an individual publisher from proceeding in an independent and competitive way if he wishes.

15. Will improved curriculums make it possible to teach a sharply increasing student population without a corresponding increase in numbers of faculty? Will it change training of teachers or alter student-teacher relationships? Can these curriculums or similar ones be employed where the objective is retraining?

15. I do not think that improved curriculums (of the kind I have been discussing) would make it possible to significantly alter the faculty-student ratio. In fact, the ratio is too high now and we need more teachers per given number of students rather than less. The new curriculums place a heavy demand on teachers as well as students.

The new curriculums should encourage significant modification of the training of teachers and I hope that teacher preparation institutions will begin to recognize this need more generally than they have. The relationship between students and teachers should change with these new science curriculums. The relationship should become one in which the teacher is more of an interested leader in a search for knowledge and information rather than an authoritative warehouse of knowledge and information. I think that the new curriculums are ideal instruments for the retraining of teachers whose original training was along traditional lines. Retraining is, in many ways, a more difficult task than training students de novo.

Response by Dr. Jerome B. Wiesner, Dean of Science, Massachusetts Institute of Technology, to Questions of the Subcommittee on Science, Research, and Development

1. We have heard the allegation that the National Science Foundation is, in a sense, becoming the creature of the university community—that is to say that virtually all of its funds are dispensed to universities. Furthermore, about two-thirds of the members of the National Science Board are associated with universities, as are most members of the advisory panels. Do you see any danger in this? Might it not be a good idea to have more representation from the nonprofit organizations, the foundations, and the business community—many of which are deeply involved with basic research?

1. When the National Science Foundation was established, the Board was created to provide a buffer between the Federal Government and the scientific community in order to insure the continued independence of the universities where it was expected that most of the research supported by the NSF would be done. Care was taken to see that the Board membership was widely representative of the research community and that its members came from all regions of the country. Because the bulk of the basic research supported by the NSF is done in universities, a majority of the Board members were drawn from the academic sphere, though its membership has always included some outstanding industrial scientists.

To the extent that the Board's primary function is to insure the well-being of the basic research effort in universities, it appears wise to continue to recruit a majority of the membership from among people closely associated with academic institutions.

Obviously, it is necessary to consider the general welfare in making policy for the NSF. Balance in the NSF program is provided by a variety of means. The nonacademic members of the Board help to some extent in this respect. The Director and staff of the Foundation, as Government employees, also have a responsibility to be concerned about broad national problems. The President, advised by the PSAC, his Science Advisory Committee, the Bureau of the Budget and his Cabinet, also has a major responsibility for establishing goals for the NSF. Finally, the Congress has always had an important role in shaping the character of the NSF program. (Unfortunately, Congress has too often restricted the scope of the NSF.) Considering the sweep of nonacademic influences on NSF policy, it probably remains desirable to draw the Board membership predominantly from the university research community.

2. In your testimony on August 3 you expressed opposition to a deliberate policy of uniform geographic distribution of NSF grants.

At the same time you advocated building up new centers of academic excellence. How do you reconcile these two views?

2. I believe that special funds should be provided to build up centers of academic excellence. Such special support should be for a finite time after which the institution thus assisted should have to compete on a basis of research competence for continuing support. Any basis for allocating research support which ignores or discounts excellence will degrade the quality of American research, damage the good schools and lower the quality of scientific education. I believe that it is possible to build up promising institutions without jeopardizing those already first rank, provided we are prepared to be careful and thoughtful, but a policy of homogenization will seriously damage our great scientific enterprise.

3. You agreed with certain committee members that more attention is needed to research in the social sciences, in order that our society may fully benefit from the advances in the physical sciences. Yet you disagreed with the suggestion that social sciences be mentioned in the NSF Act. How, then, would you propose to give status to the social sciences in the NSF program?

3. I believe that the NSF should be instructed to expand its program in the social sciences and given the resources needed to do so.

4. It has been suggested to the committee that while NSF should not attempt to evaluate the work of other agencies, it can and should evaluate the state of individual scientific disciplines throughout the Government and give weight accordingly in its research grants. Do you agree with this?

4. I believe that it would be useful to have the NSF sponsor evaluations of individual scientific disciplines. The work should probably not be done by NSF staff members for it should be done by the very best people in a discipline and few such persons are likely to be employees of the NSF. Possibly this work could be done by consultant panels working directly for the NSF. Alternatively, it might be done for the NSF by the National Academy of Sciences. Such information should be considered in planning NSF research support.

5. From the standpoint of objectives, program content, and management, which of NSF's programs do you consider to be the best, and which do you consider to be the least effective?

(a) What are NSF's notable weaknesses or deficiencies, and how may they be corrected?

5. I am not familiar enough with all of the NSF programs to be qualified to compare the various programs, but I believe that the behavorial sciences, chemistry, mathematics, educational research, and the engineering programs are inadequate. I also believe that the NSF needs to expand its scientific and management staffs. Possibly it should attract more scientists to temporary assignments with the Foundation as is done in the DOD.

(b) In your judgment what more could the Foundation do to promote the progress of science?

I believe that the NSF budget is not adequate to permit it to fulfill its responsibilities adequately. It received approximately $420 million in 1965 to support many different activities. Approximately $200 million was spent for supporting basic research, while a great variety of educational activities, including the granting of fellowships, support-

ing developing institutions, upgrading teachers and teaching facilities in high schools and colleges received approximately $120 million. About $11 million was spent on improving the dissemination of scientific information. Substantial sums were also spent on facilitating international cooperation and supporting several national scientific centers. In contrast, NASA gets more than 10 times as much money for space activities alone.

6. You indicated in your testimony that the Foundation should exercise a balance wheel function at a time when Federal funding for science and technology is changing. Can you expand on how this might be done?

6. Several of the mission-oriented agencies have found it necessary, or desirable, to restrict the growth of their basic research support so that fields which they have traditionally supported are pinched. As examples, the Navy has not been able to meet growing needs of oceanographic research, and the AEC has leveled its support for chemistry. Whenever this happens, the NSF should be directed to assume the responsibility for providing that margin of funding needed to insure that support for the particular branch of science is adequate. As part of the budget process, the OST and the BOB prepare a summary of Government support planned for the various scientific disciplines. These figures could be compared with the NSF estimate of the overall need in each area, and then the NSF could be charged with the responsibility of insuring that adequate funds were availbale for each.

7. How much basic research of interest to mission-oriented departments and agencies should be financed by the Foundation? What would be the appropriate departmental and interagency responsibilities for planning and funding and selection of fields of science and individual projects?

7. I don't think one can generalize about this. If the field of basic research is of general interest and importance, the Science Foundation should support it vigorously. If, on the other hand, the work is of little general interest and does not appear to contribute significantly to our understanding of the universe or living things in it, it is probably all right for support of the area to be the sole responsibility of a mission-oriented agency. It is extremely desirable to have more than one agency in a position to support basic research in any field. Consequently, the NSF should, in principle, stand ready to support an outstanding proposal in any field if the cognizant mission-oriented agency does not want to do so for some reason.

While it is obviously hard to defend any specific ratio, the Science Foundation portion of an important field should be sufficiently large that its policies can play a role in shaping the development of the discipline. I believe that providing half of the support for a given area would probably accomplish this.

The planning of the funding should be done by a cooperative effort involving the OST, Bureau of the Budget and NSF.

8. Considering the change in budget trends for research and development reflected in the fiscal year 1966 budget, does the President's Science Advisory Committee's manpower goal of 7,500 Ph. D.'s and 30,000 masters' degrees annually by 1970 need revision?

8. I don't believe that the PSAC goal of 7,500 Ph. D.'s and 30,000 masters' degrees by 1970 needs revision. These numbers were deter-

mined from the estimated maximum educational capability, not from a projection of need. In 1963, when the PSAC goals were set, the need appeared to be substantially larger than the targets that were established. Quite apart from the requirement for more scientists and engineers, there is a need to provide better educated people for many jobs currently filled by someone. Too many teaching positions in colleges and engineering schools are inadequately prepared, and too many important development projects are staffed and managed by inadequately trained personnel. Furthermore, I believe that it would be desirable for scientific or engineering educations to be used as the basic education for a substantial number of persons who ultimately will work in nontechnical professions.

9. What examples can you draw from your experience to show contributions by the Foundation to the shaping of national science policy within the executive branch?

9. The NSF made a major contribution to the studies which led to the PSAC scientific and technical manpower objectives discussed above. The NSF has financed many national academy studies of the scientific potential of specific disciplines, and these have been essential in the planning of science policy within the Government. In fact, NSF statistical studies have provided the basis for much of the planning that has occurred to date. Also, NSF studies of Soviet and Chinese science have played an important role in our understanding of the research efforts in these countries.

10. Do you believe that, in attempting to spread its research supporting budget over as wide an area as possible, the Foundation is spreading its resources too thin? In other words, would it be more effective to have fewer research grants funded more heavily and for longer periods of time?

10. I believe that NSF resources are spread too thin and that this does result in short-term and inadequate funding of many research projects. But given the volume of good work that needs support, I think that the NSF has done the right thing in allocating funds as they have. The money available to the Foundation for the support of basic research is grossly inadequate to support properly the wide range of activities which they must cover.

If the sole purpose of the NSF research grants was to insure performance of a maximum amount of high-quality research in the near term, it might prove appropriate to distribute the funds differently, giving more to the outstanding groups and not supporting the barely adequate groups. This would obviously be contrary to the present trend in which long-term needs, education, institution building, and geographic well-being are increasingly considered to be important.

11. How can the relatively low science education budget of the Foundation act as a balance wheel against the large sums spent in institutions of higher learning by mission-oriented agencies? Should not the NSF have a say in how all Federal basic research funds are allocated?

11. The best way for the NSF to play a more important role in determining the character of Federal support in universities is for it to support a larger fraction of the research and teaching activities that are Government financed. I believe that NSF should have responsibility for between 25 and 50 percent of the Federal support of such

activities. This goal can only be accomplished by allowing the NSF budget to grow more rapidly than that of the other agencies.

I don't believe that the NSF should have detailed control of all basic research funds, because I believe that the advantages which flow from diversity of support should be preserved, but by a combination of the integrated planning of the level of support for individual disciplines and operational coordination between agencies, coherence should be provided. Effective operation and use of the science information exchange could help greatly in this aspect of the problem.

12. How should the role of the Scientific Information Services of NSF be fitted into the total Federal scheme for collecting and disseminating scientific information?

(a) Do you believe the coordination of all scientific and technical information gathering should be the responsibility of the Office of Science and Technology? If not, what share should accrue to NSF?

12. I believe that it should be the OST's responsibility to insure that the Nation has an adequate science information system and consequently OST should assume primary responsibility for policymaking. Actual operations should be delegated to the operating agencies for work in fields where they have unique competence such as NASA for space, the AEC for atomic energy or HEW for health research. In areas where no single major competence exists, it would be appropriate to assign responsibility to the NSF.

(b) How should NSF make use of the Science Information Exchange?

The purpose of the Science Information Exchange (SIE) is to make available information on individual research projects. When I last had contact with it, its files covered the life sciences adequately, but not the physical sciences, so that it was of limited usefulness in science planning. Assuming that it can be brought up to an adequate level of coverage, it can be used by the NSF in judging the adequacy of research efforts in various disciplines, in making judgments about relative levels of support between areas and between institutions. Information stored in the SIE can also be useful in making decisions about individual grants. The information is also useful for working scientists and research supervisors.

(c) In forming the Committee of Scientific Information (COSI), the predecessor of the Committee on Scientific and Technical Information (COSATI), in May 1962, did the Federal Council for Science and Technology actually remove the coordinating responsibilities from the Foundation?

As I recall, the Committee on Scientific and Technical Information was established under the jurisdiction of the Federal Council for Science and Technology in accordance with the Executive order creating the Council. It was not necessary to remove any science information coordinating responsibilities from the NSF because they had not been assumed. Reorganization Act No. 2 of 1962 clarified the division of responsibility between NSF and OST.

13. Since it appears that the biological sciences are ready for a great expansion, what should be the respective responsibilities of the Foundation, the National Institutes of Health, the Department of Agriculture, and departments with marine biology interests for spon-

soring basic biological research and education of students in the biological sciences?

13. I don't have sufficient knowledge of the individual programs to comment on the proper division among the agencies supporting basic research in the biological sciences. NIH should continue to have a major role, but NSF should also be encouraged to have an active, growing program in this area. The Department of Agriculture has not had an enlightened approach to the support of basic research and should be compelled to develop adequate objectives and standards before it is permitted to have a substantial role in the support of basic research in academic institutions.

14. While the Foundation began as an agency to sponsor basic research, it now operates four national laboratories, directs the Mohole project, and provides major services relating to scientific and technical manpower and to technical information. What would be the advantages and disadvantages of divesting the Foundation of all operating and service functions so that it could concentrate upon basic research?

14. I believe that there is a misunderstanding here. The NSF does not operate four national laboratories; it provides funds to support research centers that are managed by nonprofit associations of universities whose faculties are interested in using the facilities. In these cases the facilities in question—for example, the National Center for Atmospheric Research—are too large and expensive to be available to individual universities and cooperative enterprises are necessary if adequate facilities are to be provided for anyone. I believe that it is proper and desirable for the NSF to support such institutions provided that it can be demonstrated that the scientific need justifies the special arrangement and, in addition, provided that a responsible management scheme can be devised.

Totally inadequate attention was paid to the preceding matters when the Mohole project was initiated. I believe that the NSF should not become directly involved in the management of research projects, as it did in this case.

If the NSF were divested of responsibility for national centers for doing basic research, this function would have to be assigned to another agency, or possibly distributed among a number of agencies. I don't believe that this would be a desirable step because it would create an artificial division between fields of academic research which required large facilities and those that did not. Such a move would certainly make the planning and coordination functions more difficult. The only motive for such a move that I know of is to make more funds available for individual project grants. Since the cost of supporting the national centers would still fall on the Federal Government, fiscal opportunism hardly seems to be an adequate reason for trading a good administrative arrangement for a poor one.

I don't have strong views on the matter of the service functions performed by the NSF and relating to technical manpower and technical information. Past efforts in both of these fields have been inadequate, and there have been numerous attempts through the years to improve and enlarge upon them.

It is now generally agreed that the NSF should not attempt to coordinate the science information programs of the Federal Government and this responsibility is now, as noted earlier, lodged in the OST. The NSF has and should continue to have an active and effective program to support translation of foreign scientific publications. Finally, I believe that the information retrieval, information processing and communication research and development programs are on too small a scale to solve the problems. Logically, the activity belongs in the Science Foundation, but if funding limitations make it impossible to support an adequate program in the information processing field without an undesirable impact on the basic research effort, the responsibility could be given to another agency.

15. Considering recent attention to the role of smaller colleges in higher education, what responsibility should the Foundation have for possibly changing the present structure of higher education by selectively directing support to smaller colleges for basic research and for education and training of scientists and engineers?

15. I believe that it is necessary to provide assistance to most of the smaller colleges if they are to develop adequate science teaching programs. The assistance must include financial assistance for salaries, for equipment, and for some research. Since most of these colleges do not and, in most cases, should not have graduate programs, the research efforts should be on a much smaller scale than in a school that has a substantial graduate training program.

It would take a major effort to properly solve the small college science program. In my opinion it is necessary to make an organizational invention to attract an adequate number of good faculty to these colleges. Several things are needed—better salaries, an arrangement that provides an association with vigorous research effort, a similar association with curriculum development activities and funds to obtain and maintain adequate laboratory and other teaching equipment.

Possibly a science corps, whose members were supported in part by the NSF and in part by the institution which they serve, could be established. Members of the science corps could spend some years teaching and others working in university research centers, in Government activities or on curriculum development programs. In this way they would be helped to retain a professional orientation. Incidentally, your questions seem to imply that the major reason for improving science teaching in the smaller colleges is to improve the education of future scientists and engineers. I believe that it is equally important to provide equally good, though not necessarily the same science education for the nonscience majors who comprise the bulk of students in the smaller colleges.

RESPONSE BY DR. NYLE C. BRADY, DIRECTOR OF SCIENCE AND EDUCATION, DEPARTMENT OF AGRICULTURE, TO QUESTIONS OF THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

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1. Earlier this summer, in a statement to the Subcommittee on Employment and Manpower of the Senate Committee on Labor and Public Works, you said that the Department of Agriculture believed it would benefit from, and would seek, broader authority and increased funds to expand its project grants.

(a) Does this imply dissatisfaction in the use of institutional grants which have been the backbone of Agriculture's support system?

(b) What disadvantages of institutional grants have you experienced that the National Science Foundation should keep in mind when planning increased institutional support?

(c) Just how should the Foundation select universities and colleges for institutional support?

(d) What factors should be evaluated besides educational merit? For example, should consideration be given to such things as geographical location; to climate, or population density or political status?

1. (*a*) The Department has sought broader research grant authority. This does not imply dissatisfaction with the statutory grants to State agricultural experiment stations, which has been the backbone of Agriculture's research support system for 75 years. It is rather a recognition of the fact that the Department's mission can best be served by a combination of research grant authorities. This has been attained recently with the enactment of Public Law 89-106.

(*b*) The disadvantages of institutional grants, particularly true when they are largely distributed by formulas as provided under the Hatch Act, is the inability to concentrate support for research on major problems in sufficient depth and intensity to attain rapid progress.

(*c*) Criteria for selecting universities and colleges for institutional support by National Science Foundation should be primarily the research training potential adjudged to exist among the institutions being considered. There should be existing competence of a relatively high degree and plans for developing and sustaining high competence. There should also be provisions for some cost sharing by the institutions.

(*d*) We believe that this Department's experience provides a good case study in the merits of providing a widely dispersed base of research institutions. Geography and population density are relevant factors in determining this base. Political status as reflecting support of local community and local or State governments also is important. This might be summarized as a philosophy which provides

for the establishment and support of research centers which nurture talent rather than simply to seek research talent and support it.

2. The subcommittee has heard arguments that the level of basic research financed by the Foundation should increase 15 percent annually to compensate for increasing enrollment and increasing costs of equipment. In your experience, has a constantly increasing research budget been necessary to achieve your goals?

2. Since the research program of the Department is strongly mission oriented, its rate of growth has been determined by the urgency of problems rather than by the increase in college enrollment and increasing cost of equipment. The annual rate of increase in funds support during the past 10 years has been of the general magnitude of 10 to 12 percent. A substantial part of such increase has been absorbed in rising costs.

3. As one of the members of the Federal Council for Science and Technology, do you feel that the Foundation should exercise a larger, or a coequal role with other agencies, in the development of national science policy? In your opinion, how has the Foundation assisted in the development of national science policy?

3. We believe that the National Science Foundation should exercise a major role in the development of national science policy, and that in general it probably should be coequal with other agencies such as the USDA. The Foundation undoubtedly has assisted materially in the development of national science policy, particularly in assuring a strong program of non-mission-oriented basic research. Its fellowship programs and the strong program of scientific information also are noteworthy.

4. The Department of Agriculture is unique in that some 20 percent of its research staff is located at State experiment stations or facilities operated by State stations. This is one approach to research and education that has not been explored by the Foundation. What does your experience with this off-site research by your staff indicate as to its value as a way to strengthen teaching of science in smaller colleges and universities that are finding it difficult to retain good science faculties?

4. The 20 percent of the Department's research staff located in land-grant college facilities are full-time research workers and have had very limited opportunity to participate in teaching programs. Teaching time with State workers is gained only by exchange of tour arrangement or teaching outside regular tour of duty. The most effective contribution is the supervision of graduate students serving as research assistants.

5. Supplementing your statement submitted to the committee on July 29, what are the long-range projections for future growth of basic scientific research activities within the Department of Agriculture?

(a) To what extent do you foresee the Foundation exercising a "balance wheel" role in regard to future research requirements of your Department?

(b) As a senior Federal scientist, how feasible do you think it is for the Foundation to attempt a "balance wheel" function in the Federal support of different fields of science?

(c) Has it succeeded in biology?

5. (a) Funds provided by the National Science Foundation have materially stimulated basic research and permitted a rate of growth

which would not have occurred otherwise. This can to some extent be viewed as the rim of a "balance wheel," in which our mission-oriented research program needs is the hub of the wheel.

(*b*) We do not view the primary function of the Foundation as essentially a "balance wheel" rather it is one of insuring an adequate total research program with major emphasis on non-mission-oriented basic research.

(*c*) Experience in the biological field tends to substantiate the above point.

6. Although the Department of Agriculture lacks authority to make training grants or to award fellowships, it has succeeded in training many young people in the agricultural sciences. How has this been done? What conclusions would you draw from this experience which are relevant to the Foundation's educational programs?

6. Research grants made by this Department have assisted in graduate training mainly because State experiment stations and other grantees make extensive use of graduate students as research assistants. Recent estimates show close to 2,000 graduate students being employed as research assistants under the match grant. This amounts to 8 or 10 percent out of the total grant. A fellowship program to bring the graduate student through the novice stage would greatly enhance the research assistantship program.

7. How does the Department coordinate its educational support with the National Institutes of Health, NASA, the Atomic Energy Commission, the Office of Education, and other Federal agencies that are concerned?

7. Since the procedure described in No. 6 constitutes the only educational support in USDA, it has not created a serious problem in coordination with other Federal agencies providing extensive support for higher education.

8. In supporting science education over the humanities or one field of science more than another, does the Federal Government incur an implied obligation to provide employment in the future for those graduates which it has supported? Do the students incur any implied obligation to stay in the field or to work on federally funded programs?

8. In our judgment the fact that the Federal Government provides support for science education ought not imply an obligation to providing employment in the future for graduates which it has supported. We strongly suspect, however, that students incur an implied obligation to stay in the field from which they receive Federal educational assistance. It is for this reason that the Department feels handicapped for the lack of any authority for fellowships and traineeships.

9. The original land-grant colleges were intended to foster both the agricultural and the mechanical arts. What would be the advantages and disadvantages of institutional grants, similar to those for agricultural research, to land-grant colleges to strengthen them as centers of modern technology? How could such a function be linked to the establishment of technical information centers under the pending State Technical Services Act?

9. With the rapid growth in the total support for research in the past 15 years, we question the need for specific support of centers of

modern technology through statutory institutional grants if a way can be found to assure that there will be a desirably wide geographic distribution of research grants under existing authority. Perhaps new authority in this area is the only way to meet the have-not situation and assure the desirable spread in geographic base.

10. To what extent does the Department of Agriculture furnish information on its research to the Science Information Exchange? What use does the Department make of the information collected by the Exchange? What has been the quality of this experience?

10. This Department provides full information on its research, both in-house and extramural, to Science Information Exchange. The Department has made only limited use of the information collected by the Exchange but is pleased with the quality of responses to our requests, particularly in biological fields.

11. In terms of upgrading the research understanding and capabilities of faculty of smaller colleges, do you think it feasible for the Foundation to consider an extension service through which competent scientists could visit, counsel, and assist other scientists in planning and carrying out their work and, in doing so, to also upgrade the quality of scientific research?

11. We foresee a need to assist in the upgrading of the quality of scientific research among the faculty of smaller colleges through counseling service, institutes and by other means. We seriously question the desirability of naming this function "an extension service."

12. The subcommittee has heard convincing testimony that the coming years will open a new age for applied biology. Assuming this is so, what should be the future relationships and responsibilities of the Foundation, the National Institutes of Health, and the Department of Agriculture for the support of biological research?

12. We foresee an increasing need for a close working relationship with the National Science Foundation and other Federal agencies engaged in biological research, particularly National Institutes of Health but including U.S. Department of the Interior, Atomic Energy Commission, Department of Defense, and National Aeronautics and Space Administration. The Office of Science and Technology can be very helpful in the establishing of interagency committees and task forces as mutuality of interest indicates to be necessary. Frequently the agencies concerned will formally establish work groups as illustrated by our present Interdepartmental Committee on Pesticides. Other current problem areas involving good interdepartmental cooperation include aflatoxin, leukemia, tobacco, and health, and water pollution. By appropriate use of interagency planning bodies, the mission-oriented agencies and the National Science Foundation each can delineate its appropriate role in the overall effort.

13. The point has been brought during the hearings that certain research projects are referred to NSF by other Government agencies. This raises the question of how one determines if a certain research project should be funded, say, by agency X, agency Y, or both. Specifically:

(a) What guidelines or criteria has Agriculture established to aid contract or grant administrators in determining if a certain research project is, or is not, within the purview or scope of the

Department's jurisdiction and, therefore, should, or should not, be supported?

(b) If written criteria have been established by the Department, please submit a copy thereof to the committee.

13. This Department does not have written criteria to be used in determining whether research proposals are, or are not, within the scope of the Department's jurisdiction. We do, however, give careful consideration to any given proposal to determine Department consensus, or jurisdiction based on the general mission of the Department. More specific criteria are being developed as part of a long-range study of agricultural research in which we currently are engaged.

APPENDIX 3

PREPARED STATEMENTS

STATEMENT SUBMITTED TO THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT OF THE COMMITTEE ON SCIENCE AND ASTRONAUTICS, HOUSE OF REPRESENTATIVES, BY LEE A. DUBRIDGE, PRESIDENT OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY, JUNE 22, 1965

Gentlemen, I welcome this opportunity of submitting a statement to the Subcommittee on Science, Research, and Development relating to the work of the National Science Foundation.

I speak on this subject with a background of two kinds of experience:

(*a*) I served as a member of the National Science Board for 10 years—from 1950 to 1954, and from 1958 to 1964. I was Vice Chairman of the Board from 1962 to 1964.

(*b*) I am president of the California Institute of Technology, an institution which has many scientific research projects supported by the National Science Foundation and which has been the educational home of many students who completed their undergraduate work here and then went on to other institutions with NSF fellowships—as well as being the chosen institution for the residence of many NSF predoctoral and postdoctoral fellows.

I should like to begin by expressing my opinion that the National Science Foundation is one of the most important agencies ever created by the Congress of the United States. It is hard to see how the United States could have risen to and maintained its present position of world leadership in the field of science without the National Science Foundation. It seems clear that maintaining this position in the future will be even more dependent upon the work of NSF and its understanding support by the Congress.

Although a number of Government agencies participate in the support of scientific and engineering research in universities throughout the country, the NSF still occupies a unique position in this area. The other science-supporting agencies are "mission oriented" and are charged with supporting those areas of research which are either in the near or long term related to various missions.

However, the broad field of science is not covered by mission-oriented support since many important areas of research cannot be clearly identified with these various missions. It has been precisely one of the great values of NSF that it has been able to support basic

research on a broad front without regard to visible or immediate practical applications. Nevertheless, many practical applications have emerged from the work of NSF, and its research support includes many areas of great value to the national interest.

In addition to its research support, NSF has played a critical role in advancing our programs of higher education for scientists and engineers. Without the NSF fellowship programs, the number of scientists and engineers trained in this country in recent years would have been very much smaller, and our scientific leadership thereby would have been impaired. The excellence of our educational programs has been substantially enhanced both by aiding the universities to enlarge their facilities and their research activities in which graduate students participate, and also by making it possible for many graduate students to pursue advanced educational programs which would have been beyond their financial means had NSF fellowships not been available.

The basic policy which has guided all of the activities of the NSF, and which should never be abandoned in its future work, is that of the support of excellence. The NSF seeks to support excellence wherever it may be found. It supports those research projects judged by committees of experts to be of the very greatest promise in producing new knowledge, and it awards fellowships to those students (predoctoral and postdoctoral) whose records and achievements indicate high promise that they will become productive scientists in the future.

It is of the greatest importance that the Congress impose no limitations on the activities of the NSF which will interefere with its policy of the support of excellence. The great advances in science come not from the mass efforts of large groups of mediocre people, but from the imaginative leadership and ideas of a relatively small number of individuals. The NSF should seek out these highly competent individuals wherever they may be found and provide them with the facilities and staff to pursue their productive work.

As we look to the future, there are several areas of NSF activity and policy which I should like to discuss which will require full understanding and support by the Congress:

1. BASIC RESEARCH IN UNIVERSITIES

In spite of the rather large and widely advertised expenditures under Government grants and contracts for certain areas of research (space, defense, biomedicine, atomic energy, etc.), the fact remains that the total funds available for basic scientific and engineering research in universities are still inadequate. Many important fields are still hard pressed for adequate support. The rising costs and need for facilities in optical and radio astronomy justify very substantial increases in support during the coming years. Similarly, in chemistry, in solid state and low-temperature physics, in geophysics, and in a number of areas of basic research in applied science substantial additional funding will be needed over the coming years. The NSF funds for basic research grants to universities should be doubled in not more than 5 years.

2. NATIONAL RESEARCH CENTERS

The continued support of the national research centers in astronomy, radio astronomy, atmospheric science, plus the continuing support of special projects, such as those in oceanography, the Mohole project, etc., should not be confused with the general support of university research. These national projects should continue to receive the increasing support required to maintain their excellence and viability. But this should not be at the expense of the research grant budget. Some of these special enterprises, such as the NCAR Laboratory at Boulder, are just getting underway and will need considerably increased support during coming years to reach the level of activity and effectiveness originally visualized. Large capital expenditures will also be needed at the astronomy and radio astronomy centers at Kitt Peak and Green Bank, respectively. Every effort should be made to meet the required budgets of these important national activities during the coming years.

3. PREDOCTORAL AND POSTDOCTORAL FELLOWSHIP PROGRAM

This has been one of the most valuable of all NSF activities. It has helped greatly to encourage able scientists and engineers to pursue their graduate and postdoctoral studies. It has enhanced the ability of universities to accommodate more students and to improve the quality of their education. These programs are well established and face only two problems during the coming years:

(*a*) To increase the total fellowship funds as educational costs rise and as the total graduate student population rises. It would be desirable to maintain NSF fellowships for approximately the same proportion of all graduate students as at present.

(*b*) To impose no restrictions which would preclude the award of all fellowships on a straight merit basis. Artificial and unrealistic geographic restrictions are not in consonace with the national interest, which should seek to support the best and most promising students wherever they are found. This policy has already resulted in a most equitable national distribution, and restrictions imposed for political reasons would be damaging to the program and against the national interest.

4. THE PAYMENT OF "FULL" COSTS OF UNIVERSITY RESEARCH PROJECTS

It is encouraging to note that the Congress is apparently eliminating the unrealistic limitation in the payment of "indirect" costs to a maximum of 20 percent of direct costs. These indirect costs are just as real as the direct costs, and the failure of Congress to allow the indirect costs to be fully covered in university grants has resulted in heavy burdens on colleges and universities throughout the country who are energetically seeking to enhance and improve their research activities because of their contribution to the national interest. It is hoped that all agencies administering research grants will be freed to pay full audited indirect costs in accordance with polices and procedures which have already been established in connection with research contracts by the Bureau of the Budget.

In connection with this matter, there has, however, been a misunderstanding about the desirability of a university "participating" in the support of research. Of course, the university should "participate"; but what is often overlooked is that the university inevitably and automatically participates. To be a center for basic research at all, a university must have built its plant and acquired the staff for both its educational and research enterprises. No university research project exists in a vacuum. It must be a part of an on-going institution which has graduate and undergraduate students, which has a physical plant, library facilities and a well-rounded faculty covering all appropriate academic fields of knowledge.

Even when the identifiable direct and indirect costs of a particular research project are covered by a Government grant or contract, this project still depends upon the total university environment in order to exist and be effective. Only a very few American universities which have given great emphasis to research find that their Government support of research equals as much as half of their total annual budget. For most institutions the percentage is very much less. And yet the total activities of the institution contribute to every single research project—even including those expenses directed primarily at instruction, since education and research are so intimately tied together in a university, each supporting and improving the other. All universities are hard pressed to maintain their total programs and to maintain the strength required to support those research activities which are deemed worthy of Government assistance. Hence, in identifying the university "participation" one must examine the entire program of a university and note what a very large fraction of this total program comes from the university's own private (or State) sources. The policy of the Government should be to enhance the strength of the total university operation and not insist on the diversion of funds from hard-pressed budgets to pay out-of-pocket costs connected with research projects which, in the judgment of the particular Government agency, are deemed worthy of support.

I very much trust that the Subcommittee on Science, Research, and Development will set forth, most emphatically, the enormous value of the National Science Foundation to the national interest and to the progress of our civilization, and will strongly advocate continued understanding and financial support of the National Science Foundation programs.

STATEMENT OF THE AMERICAN INSTITUTE OF ARCHITECTS BEFORE THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT, COMMITTEE ON SCIENCE AND ASTRONAUTICS, HOUSE OF REPRESENTATIVES, JULY 28, 1965

I am Benjamin H. Evans, AIA, an architect and director of research programs for the American Institute of Architects. This testimony was to have been presented by Mr. William H. Scheick, FAIA, executive director of the institute, who could not be present due to an unavoidable commitment.

Before assuming my position with the institute, I was head of the architectural research group at Texas A. & M. University and associate professor of architecture. My experience includes teaching, research, private practice, and consulting work for over 150 architectural and industrial firms. My advice to the American Institute of Architects on building research is based on this experience. Nevertheless, the following statement is not personal, but reflects the attitude of the American Institute of Architects Committee on Research for Architecture, and the institute.

I appreciate the opportunity to appear before you to discuss the National Science Foundation and its relationship to what I call the building construction sciences.

The National Science Foundation has, of course, played a vital role in developments in science and technology in this country during the past 15 years. However, its involvement in the building sciences specifically has been limited. The American Institute of Architects and the National Science Foundation have had excellent relationships through the years and several fundamental projects in the architectural field specifically have been supported by the Foundation. Admittedly, the number of projects supported in architecture, building science, and the related areas has been comparatively small. But it is our hope and expectation that projects in these areas can be increased considerably in the ensuing years. Let me explain briefly why we think there is a serious need for greater National Science Foundation activity in these areas, and describe the kinds of projects with which we are concerned.

It has been said that more buildings and structures will be built in the United States in the next 40 years than have been built since the beginning of our country. Such an expansion of construction will be necessary to meet the needs of the rapidly expanding population. The problems of planning, constructing, coordinating, and administrating our rapidly expanding urban areas are well known to most of us. The problems of blight, poverty, and ugliness, of the serious lack of open spaces, recreational areas, and transportation, are known to most of us. Such conclusions indicate that considerable intelligence and effi-

ciency will be required in solving these expanding problems—economic, social, and technological.

There are many areas of fundamental knowledge in each of these fields that have yet to be thoroughly explored. At our current rate of attack on these problems, the answers will come too late. They are too late already. If we are to be prepared for the job that lies ahead, more attention must be applied.

Much research is being done and has been done, of course, which will contribute significantly to the solution of these problems, but the concern here is with the rate at which problems are being attacked.

There are three aspects of the situation that need attention. First, there is the need for more concern by the Government for assuming a vital role in an area which needs attention and which promises such significant benefits for the public. Second, there is the need for more highly qualified people to do research in these areas. Under the present state of conditions, our brightest young men are not being attracted to the building science areas, but to areas of science which are more exotic, such as in the physical science (electronics, space exploration) and where there are more significant programs of science with greater and more stable financial support. Third, there is the need for more extensive research programs at the universities which deal with the problems of man's built environment, particularly in architecture, planning, landscape architecture, and the allied engineering fields. There is a need for stimulation of a greater emphasis on building research in the professional curriculums and on building research programs at the graduate level.

This leads to the conclusion that NSF, as the cornerstone for scientific development in this country, should increase its efforts in the development of institutions and programs for the building sciences, in addition to increasing its support of specific scientific questions related to the building sciences and the problems of the urban society.

I suspect that the definition of science as used by NSF tends to be too restrictive. There should be greater concern with the science of people and their behavior, with the interaction of people with their environment, and with society and the problems of providing adequate and appropriate shelter, transportation, communications, disposal systems, power supplies, and so forth.

These problems are not uniquely the province of the architects or of the others intimately involved in the building sciences. It is in many respects, the problem of all disciplines and every citizen. However, the architect, the planner, the landscape architect, the allied engineering specialists, all have fundamental and unique contributions to make and certainly will add breadth and depth to the development of knowledge about communities, cities, and their people.

So, then, new ways must be developed to stimulate and support research into scientific problems that underlie the human, technological, and environmental areas of the urban society. These studies can most logically be carried on at the universities, where qualified personnel are most likely to be found and where students will be attracted to the field. But stimulation of activities here will require not only a more intensive effort within the National Science Foundation, but it will also require leadership from NSF, since there are too few people working in these areas now to keep up with the demand for new knowledge.

In 1959, the National Science Foundation, through a grant to the AIA supported a Conference on Basic Research in Architecture at Ann Arbor, Mich., to which scientists from many disciplines were invited. For 2 days and nights they explored areas of concern.

Among the types of problems which that conference pointed out as essential for exploration—and which the AIA feels are appropriate for NSF support—are the following: studies to determine more completely the effects of environment on human beings; the reactions of people to sound, heat, odor, color, texture, light, the geometry of space, and so forth—the psychological reactions as well as physiological reactions; studies of the economics of land acquisitions, systems of building construction, land utilization, labor utilization, space design, mechanical systems, and so forth; studies to develop technological innovations in structural systems, power supply systems, environmental controls, space enclosures, communications systems, and so forth. This does not, of course, include the development of products and materials that have proprietary interests.

Such a list could be extended almost indefinitely, but these few points indicate the broad scope of activities in the building sciences which might legitimately receive NSF support, and which under present conditions are developing much too slowly.

Another pressing concern has to do with the proposed National Foundation for the Arts and the Humanities. While I have discussed here the building construction field as it is related to scientific activities, there is also that side which deals with the arts and humanities. The AIA supports the development of the Foundation for the Arts and the Humanities and sees it as helping to balance Federal support in science and technology. It is important to recognize the need for activities in both areas, since building is both an art and a science. This also points up the need for some clarification of the respective roles of the Foundations and the need for cooperation between them. We take cognizance of the letter, which is attached to this statement, from Prof. Burnham Kelly, AIA, dean of the College of Architecture at Cornell University and a member of the Commission of Fine Arts, to the Honorable Adam C. Powell, regarding the importance of good relations between the Foundations.

In conclusion I reiterate the urgent need for more fundamental research dealing with the many and broad aspects of architecture and building science. Such research activities must be stimulated by a greater awareness of the need for further scientific study, by the development of more institutions to conduct scientific research, by the encouragement and development of more scientific personnel, and through the application of more funds to such studies. We believe the National Science Foundation is the logical and appropriate place for such activity and leadership.

COMMISSION OF FINE ARTS.

HON. ADAM C. POWELL,
House of Representatives,
Washington, D.C.

DEAR MR. POWELL: As a member of the Fine Arts Commission and as dean, College of Architecture of Cornell University, I feel compelled to address this letter to you.

It has been the intention of Congress to establish new foundations to serve the areas of the humanities and the arts which have been notably neglected in the past in favor of such disciplines as medicine and the sciences. As Congress

deliberates this move it is its intention to avoid duplication in the functions of such foundations. This is understandable; however, it is important to recognize that broad disciplines cannot be easily assigned to one or another of such foundations, and that particularly some of the most important professions such as architecture may very well be completely neglected because of the tendency of each of the foundations to say it properly belongs to one of the other.

In the healthy development of the profession of architecture, it may not only be possible but absolutely necessary to have in simultaneous operation a study of some aspect of science and technology under the Science Foundation; a study of some aspect of human social relations under the Humanities Foundation; and a study of some aspect of design and the arts under the Arts Foundation. Architecture cannot fulfill its function and its public mission if it cannot operate in all three areas at the same time. In fact, of course, it does.

The experience of the profession of architecture has been that foundations and other sources of support tend to regard it as an anomaly and not easily classified and therefore it tends to be excluded from each office to which it applies. If this is done in the new foundations, the Government is unduly penalizing the architectural profession because of its comprehensive point of view. The reverse should be true. The interest of the public is very strong in having a profession which does attempt to synthesize and analyze the scientific, humanistic, and artistic disciplines for the enhancement of the natural and manmade environment of our citizens.

Sincerely,

BURNHAM KELLY, *Vice Chairman.*

STATEMENT PREPARED IN THE DEPARTMENT OF AGRICULTURE IN RESPONSE TO THE JUNE 9 MEMORANDUM FROM CONGRESSMAN EMILIO Q. DADDARIO, CHAIRMAN, SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT, IN CONNECTION WITH ITS REVIEW OF THE NATIONAL SCIENCE FOUNDATION, BY DR. NYLE C. BRADY, JULY 29, 1965

INTRODUCTION

On behalf of the Secretary of Agriculture and his staff, I express our appreciation for the opportunity afforded for us to participate in the comprehensive review of the National Science Foundation.

During the 15-year history of this well-conceived institution, it has grown steadily in stature and has established itself as an essential element in the science structure of the Nation.

The Department of Agriculture, being strongly mission oriented, has encouraged, sponsored, and supported basic research to the limit of its capability. At the same time, it is completely sympathetic to the goals of the National Science Foundation, recognizing that it has and will continue to play a unique role in giving greater purpose and direction to the Nation's total basic research effort. In so doing, we see no curtailment of opportunity for the support of basic research in our Department, or in other mission-oriented scientific establishments, in or outside of Government.

BENEFIT TO ALL GOVERNMENT AGENCIES

The Department in common with other departments and agencies of Federal Government has benefited from the outset by the programs carried out by the National Science Foundation. Its program for support of basic research and supporting facilities has greatly stimulated the program of basic research beyond that which would have been accomplished through the regular programs of the mission-oriented agencies.

Nonprofit agricultural research institutions have shared in National Science Foundation grants for basic research from the beginning of its research grant program. Scientists at the State agricultural experiment stations have consistently been awarded 2 or 3 percent of the total grants for the basic research made each year by the Foundation. Also the Foundation's support for research facilities at many of the land-grant universities, particularly those for biological research, have been of great value in permitting a more comprehensive research program in this area.

The Foundation's support of science education programs also has become a major factor in stimulating a continuing supply of well trained young scientists. This Department, lacking any legal authority for fellowship or trainingship programs, has particularly looked

to the National Science Foundation to provide the incentives and the financial assistance so essential to encouraging graduate training in the many disciplines essential to the continuing sound program of agricultural research.

This Department views with some concern the lack of uniformity among the major research agencies of Government to the support for science education. We suggest that authority in this field be extended to all interested mission oriented research agencies or that it be centralized in the National Science Foundation.

Other aids to education, particularly the institute programs, have had a major impact on improving the quality of science instruction in the Nation's secondary schools. We have viewed with interest the recent efforts to expand the institutional science programs supported by the National Science Foundation. This Department is highly sympathetic to this objective since our long history of institutional support for agricultural research in the land-grant colleges and universities and the resulting growth of centers of recognized merit in every State gives support to the soundness of this program. The direct support to enhance science facilities for graduate training in many institutions is also proving its worth.

The Department also strongly endorses the support for science information services which in recent years has become a major part of the Foundation's program. The National Agricultural Library has worked closely with the Office of Science Information of the National Science Foundation since 1958 when NSF began its expanded interest in governmental activities in the science information field.

The National Defense Education Act of 1958 which established the Science Information Service included a "Science Information Council" to be composed of leaders in the fields of librarianship, scientific documentation, the sciences and the lay public. The Director of the National Agricultural Library has served as an ex officio member of the Council since its establishment. Members of the library staff have served on various committees set up by OSIS in the field of librarianship, documentation and coordination of library activities.

Direct support was furnished by the National Science Foundation to the National Agricultural Library in 1961 for the study and evaluation of the need for an oriental division in the library. Support was provided on a 2-year basis and enabled the library to assess its oriental holdings which had been built up over a period of a hundred years. The study indicated an urgent need for special attention on the part of the library to its oriental materials. A section was established by the library to handle these publications and this is now being carried on as a regular library activity.

There have been no areas of joint support for research, although the library has provided advice on various programs which were under consideration by NSF. In addition, research studies conducted by or through NSF have been of value to us. An example is the current study of journal literature.

From close working relationship with NSF we are convinced that it does perform a very important function in coordinating activities in the science information field and in providing a base for research in the documentation and science information area. There is a need for further clarification of the responsibilities of NSF in the science

information field. During the past 7 years there have been many changes in the programs and objectives as well as the responsibilities of the Science Information Service. It would be helpful to all Government agencies if a long-term policy could be established for the Office of Science Information Services.

We have followed with a great deal of interest the evaluation of the mechanism for science policy planning in the Federal Government. We recognize that responsibility originally assigned to the Foundation in its basic legislation "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences," posed a very difficult problem for an agency which also had major operating responsibilities. In our judgment, the transfer of much of the national policy and coordinating responsibility to the Office of Science and Technology has made the Foundation much more effective in its major areas of activity as discussed above.

We particularly commend the Foundation for the comprehensive surveys which it makes of the research and development effort of colleges and universities and other nonprofit institutions and of industry. Also, we have been an enthusiastic supporter and user of the annual summary of Federal funds for science. The flow of information from these surveys by the Foundation is of inestimable value in sound research planning for the Nation.

NSF–DEPARTMENT OF AGRICULTURE RELATIONSHIPS

The Department agencies having a major responsibility for agricultural research have shared many problems with and derived many direct benefits from the NSF.

Cooperative relations between the Forest Service and the National Science Foundation are largely associated with a program of study, research, and evaluation in the field of weather modification. Since 1960, NSF has given direct support amounting to $344,000 to our Forest Fire Laboratory, Missoula, Mont., to carry out investigations in the general area of weather modification as related to forest fire control. In addition, our Director of Forest Fire Research participates in the NSF Interagency Committee on Weather Modification. The Forest Service also prepares information annually for the NSF report on weather modification. At the request of NSF, forest fire research scientists assist in the review and prepare recommendations on proposals for basic fire research. At the invitation of NSF, forest fire research scientists participate in special symposiums and conferences on atmospheric sciences. Three examples of such participation during the current year are the NSF symposium on mathematical models and statistics in weather modification; NSF symposium on the economic and social aspects of weather modification; and the Conference of the NSF Weather Modification Commission. The Foundation has done a good job in monitoring and coordinating national research efforts in the areas of atmospheric science and weather modification research and has given excellent support to this program.

Cooperation in other areas of forestry research has been somewhat more limited. The Division of Watershed, Range, Wildlife Habitat and Recreation research has provided specialists for reviewing and evaluating grant proposals for both the Regulatory Biology and the

51-204—65—vol. II——36

Environmental Biology Branches of NSF. This is to continue at the request of NSF.

Of considerable significance is the NSF support of basic forestry grants at institutions of higher learning amounting to $1.4 million in fiscal year 1965. This may be compared to the Forest Service grants program, including both Whitten Act (Public Law 84–473) and basic research (Public Law 85–394), amounting to about $1 million in fiscal year 1965. It is apparent that the NSF grants add strength to the Nation's forestry research program at various universities.

The Agricultural Research Service has shared with the Foundation the sponsorship, planning, and joint financing of many interesting projects over the years. These include such undertakings as:

Symposium on Radioisotopes in the Biosphere.
Fifth International Congress on Nutrition.
Symposium on Mutation and Plant Breeding.
Symposium on Statistical Genetics and Plant Breeding.
Symposium on Plant Pathogens in Soil.
XVIth International Congress on Zoology.
31st Meeting and Congress of the International Federation of Documentation.

The Department is cooperating with the Foundation on the translation of scientific articles and books originating in Russia, Poland and Yugoslavia. To facilitate this program, the Department has transferred to the Foundation during each of the last 2 years the equivalent of $100,000 in Israeli pounds. This program is authorized under Public Law 480, section 104K. The foreign currency available to the Department appropriations comes from the sale of surplus agricultural commodities for the currency of the country. The special foreign currency funds available to the Department are appropriated by Congress. Under this program many useful East European articles dealing with agricultural research have become available for our scientists.

Based on cooperative experiences the administration of the Agricultural Research Service has placed particular emphasis on two major purposes which the NSF has served in Government:

(1) To provide an avenue of support of the scientific disciplines in American science without regard to the missions of the other Government departments. This has contributed in a major way to increasing the fund of knowledge and the pool of competent scientists from which Agriculture, among others, draws for its personnel.

(2) To function in effect as a "national science contingency fund" to assure prompt attention to important emerging problems in science prior to the time that the "line" agencies of Government can provide appropriate attention to these problems through the budget process. The capacity of the NSF to perform vital functions of this type should not be impaired.

The Cooperative State Research Service, the Department agency charged with the administration of the statutory grants to State experiment stations and related research grants, has cooperated closely with the Foundation in strengthening the programs of these nonprofit research institutions. The support made by the Foundation to programs of basic research in these institutions has strengthened

the base for the total program of agricultural research and at the same time has attracted many graduate students, serving as research assistants to training in those disciplines so essential to a sound program of agricultural research.

In this connection, the special development programs of NSF is particularly noteworthy. This program to identify and support the development of centers of excellence in science in all areas of the United States has great potential and inevitable impact on the mission-oriented research of the Agricultural Experiment Stations, themselves centers of excellence in agricultural research in varying degrees. We shall try to be fully informed of status of this program and seek in appropriate ways to enhance the capacity of the land-grant universities of which the respective SAES are a part, to qualify as centers of excellence in areas of science relevant to agriculture, especially in the social sciences which are inadequately supported.

In conclusion, we wish to reiterate our belief that NSF is filling and should continue to fill a highly important role in the development and presentation of a national science program. We look forward to further effective cooperation with the Foundation in the strengthening of this program.

STATEMENT OF DR. JOHN W. GARDNER, PRESIDENT, CARNEGIE FOUNDATION, BEFORE THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT OF THE COMMITTEE ON SCIENCE AND ASTRONAUTICS. AUGUST 3, 1965

I want to talk about the relationship between the National Science Foundation and the universities.

When Representative Daddario asked me to testify, he suggested that I might wish to comment on "the relationship, current and potential, between the National Science Foundation and private foundations." I have given a good deal of thought to the matter, but I must say candidly that in my judgment that relationship will not shed much light on the problems of the National Science Foundation and its future. At the time the National Science Foundation was created, the great private philanthropies of this country provided an important model for the new agency. The very word "Foundation" in its title reflects that fact. The relationship the National Science Foundation maintains with its grantees, and many of its other procedures and policies were pioneered years earlier by private philanthropy.

But, generally speaking, the time when the National Science Foundation had major lessons to learn from private philanthropy is past. The National Science Foundation has done its own pioneer work in the field of giving, and many of the private foundations would profit by closer examination of that work.

The other question of interest is whether we should look toward some division of labor between public and private programs in support of research and teaching. One hears it said that when public money comes into a field, private money leaves that field. This suggests to some people that public money should stay out of certain fields altogether. I would have difficulty accepting any such solution, but I cannot deny that the problem is real. The best that can be said is that we are all still groping toward an answer—and, of course, there may be no tidy answer.

So now, Mr. Chairman, with your permission, perhaps we may turn to a matter on which I can express more definite views—the relationship of the National Science Foundation to the universities. To state the problem more broadly, I'm concerned about the relationships of all Federal agencies with non-Federal educational and research organizations (private and public colleges and universities, independent research organizations, libraries, and so forth).

This is a part of the larger question of the role that Government is to play in our society. It is a question that every intelligent citizen has worried about. One hears it said that Government is gaining increasing dominance in our lives and that the private sector is losing ground. Is that true? One hears it said that the Federal Establish-

ment is becoming all-powerful, at the expense not only of the private sector but of the State governments. Is that true?

One encounters extreme proponents of one outcome or the other. Some are pathologically afraid of big government and would like to diminish the governmental role almost without limit. Others are just as extreme in their advocacy of doing everything through the Federal Government. For my part, I believe that the vitality and creativity of our society will best be served by maintaining the vigor of both governmental and nongovernmental sectors. I certainly do not wish to see excessive centralization of power. But some of our shared purposes can be advanced only through action of the Federal Government.

We face an array of pressing problems. In many cases the old methods and instrumentalities for solving those problems are no longer adequate. We Americans are nothing if not purposeful, and when we can't solve our problems by the old methods we are going to try new methods. Despite the fact that few of us really want to enlarge government, we have seen, in recent years, the emergence of many governmental functions which one would not have dreamed of a generation or two ago.

I was greatly encouraged by the fact that the Federal Government, beginning with World War II, and continuing through the 1950's, developed an enormous range of contractual relationships with nongovernmental organizations and agencies. These encompassed not only defense contracts with industry but relationships with universities and independent research laboratories. It seemed to me that in the great flexibility of the contract and grant relationship, the Government had hit upon a significant way to accomplish public purposes without the endless enlargement of the Federal Establishment. It was clear that such contracts and grants, properly used, could further the shared purposes of the American people. And at the same time they could strengthen the nongovernmental institutions that have contributed so greatly to the richness and diversity of our social processes.

Of course, we all know now how very complicated those contract and grant relationships can be. In the case of the industrial contracts, some Government people honestly believe that industry has grown fat at the Government's expense. In contrast, many in industry today are saying that the screws have been so severely tightened on contract relationships that the industrial contractor has become, for all practical purposes, an arm of the Federal Government. According to a third view, gloomier perhaps than either of the others, industry is not bilking Government nor is Government dictating to industry, but the two have entered into an unholy alliance at the expense of all the rest of us.

I take still another view. I believe that the Government-industry contract presents inherent difficulties but also great benefits for both sides; and I believe that with patience, imagination, and statesmanship, the benefits can be maximized and the difficulties reduced (though never to zero).

I take the same view of the relationship between Government and the universities. The partnership can be an exceedingly fruitful one despite its complexities.

An understanding of the complexities cannot be arrived at if we insist on clinging to old cliches and categories. In this connection I should like to quote from a speech I gave on the subject last year.

Do the emerging relationships with the universities and with industry represent an increase in Government power or a decerease? A centralizing trend or a decentralizing trend? When one considers that many industrial concerns and universities are now, in some measure, dependent on Government support, one is inclined to see the new trend as a growth in Government power. But to the old-line Federal official, used to a world in which Government funds were spent for purposes defined by Government and administered by hierarchically organized departments under complete Government control, the new trend looks like a grievous loss of Government power. He can't appraise what it is doing to industry and the universities, but he knows that it is having a profound effect on Government. Wherever he looks, he sees lay advisory bodies recommending how Government money should be spent, and nongovernmental organizations spending it. Both industry and the universities spend their Government contract money to outbid Government in hiring of scarce personnel. The universities, particularly, insist that the money be spent in ways that they themselves define, and they do not welcome the advice of well-meaning Government officials. It is difficult for the Federal official to observe all this and feel that his power is growing.

The new partnerships cut across the old public-private categories as well as the old centralization-decentralization categories. A new sort of relationship has been created and we are going to have to judge it by new criteria. Furthermore, it is a relationship that it still evolving, so we still have a chance to shape its future course.

In the same speech I commented on the nature of the tensions between Government and the universities:

When Government agencies and universities work together, there are predictable sources of difficulty. The agency tends to surround the relationship with more and more defining conditions, until the university's freedom of decision is undermined. This does not reflect a sinister desire to diminish anyone's freedom. It stems from the nature of Government responsibilities and habits of mind. The remarkable thing is not that all agencies show these tendencies, which they do, but that some agencies have had the wisdom to curb them.

Just as the Government agency tends to tighten the defining conditions of the relationship, so university people seek to loosen them. They tend to push all contracts and grants in the direction of the general support grant—fewer conditions, more freedom to define objectives, and greater continuity of support.

Underlying these differing approaches is a fundamental difference of outlook on the issue of accountability. The accountability of the university varies, of course, with the various kinds of contracts and grants. In basic research grants it may be limited to the barest minimum of fiscal reporting, but in contracts it may be more complicated. It is not easy for university people to understand that the Government lives by accountability (and no one would wish it otherwise)—accountability to the taxpayer, to Congress, to the General Accounting Office, and to the White House. In most contract procedures, the Government agency has delegated some of its powers to a private organization. Naturally it tends to want to impose on that organization the same accountability it requires of itself. What it fails to understand, of course, is that excessive zeal in demanding accountability may create intolerable conditions for the universities with which it is dealing.

Just as the Government agency is often too rigid in demanding accountability, so the university is sometimes too careless. The university should sympathize with the Government's basic problem and should focus its criticism on those forms of accountability that are clearly inappropriate to a university. When it can serve the Government's requirements without damaging its own position, it should do so.

Now let me return to the National Science Foundation. Perhaps more than any other agency of Government it has sought to deal wisely and farsightedly with the universities. No one would pretend that it has escaped the complexities of the relationship or that it has been without fault; but it can be proud of its record. And it can serve as a

valuable model in the years ahead. A fruitful relationship between Government and the universities is essential to the continued creativity of our society. I say that with all the emphasis that I can bring to it. All departments of Government are going to have to deal eventually with the universities, independent research laboratories, and other nonprofit institutions. No department can any longer afford to be wholly cut off from the sources of new talent and innovative research. Some Government departments, having had little experience with the relationship, are fumbling badly in their dealings with the universities.

We are still in the process of discovering the forms and modes of relationship that will make creative partners of Government and the universities. No agency of Government is in a better position than the National Science Foundation to advance that process of discovery.

The aim is to give Government agencies access to the creative potentialities of the universities, and the universities access to the resources of Government. Conditions of the relationship must be so defined that irresponsible (or careless) elements in the university community will not show a wanton disregard for the taxpayer's dollar and, at the same time, that the responsible elements in the university community will not be paralyzed by Government redtape. The two objectives sometimes seem wholly incompatible. The faithful Government accountant builds a network of regulations to protect the taxpayer, and the university is imprisoned therein. We are far from having arrived at a stable and workable philosophy to govern the relationship. There have been regrettable examples of carelessness with Government money. But at the same time we must establish some limit beyond which the chasing of dimes in behalf of the taxpayer yields to a respect for university autonomy and the requirements of creative work. Innovative work is rarely done in the presence of an overeager accountant. The future is rarely shaped by men who are busy devising (or abiding by) foolproof regulations.

The National Science Foundation, like the National Institutes of Health, has come increasingly to view our educational system and our great universities as national resources to be preserved, strengthened, and developed. Increasingly, it has looked beyond the urgencies of the moment to the longer term needs of these institutions.

But though one must give the Foundation great credit for what it has done to date, it seems to me that it has barely scratched the surface. Our great universities are national resources of a very special kind. They are the creative sources of a complex technological society. The Foundation should think more systematically and more boldly about the long-term implications of that fact and the long-term strengthening of those institutions. And it must discover how to do this in such a way that the universities preserve their heritage of freedom. If it succeeds in this, it will have done the Nation an unprecedented service in planting the seeds of future greatness.

We are not in the habit of thinking nationally. We are not really a very planful people. But our society is now so intricately organized and interconnected, and the pace of history has so drastically quickened, that we have little choice but to look ahead more systematically than we have to date. If we do so, we shall see that there are great and exciting tasks to be accomplished. Through a wise and imaginative strengthening of the universities, we could begin today to create the foundations for a greater America for our grandchildren.

STATEMENT BY DR. ARTHUR F. SCOTT, PROFESSOR OF CHEMISTRY, REED COLLEGE, PORTLAND, OREG., TO THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT, HOUSE OF REPRESENTATIVES, AUGUST 4, 1965

The training of U.S. scientists at all levels of our educational system is currently under review and study. It is imperative that all facets of this exceedingly complex problem be illuminated and scrutinized because the conclusions to be drawn and the decisions to be made are crucial to the future development of science and technology in this country.

This memorandum is intended to throw light on certain aspects of the education and training of scientists at the undergraduate or college level. It presents a specific recommendation which, it is believed, will strengthen the training of scientists at the undergraduate level.

Specifically, this memorandum is concerned with three basic factors which, conceivably, may have some bearing on the accomplishments of an institution's baccalaureates. These basic factors are—

Type of control of institution (private-public).
Size of institution (large-small).
Resources or "strength" of institution.

HISTORICAL NOTE

For roughly 200 years, higher education in this country was the responsibility of private institutions, many of them church related. Around the middle of the last century, the traditional system began to change as the result of various social and economic pressures: instruction in science began to be accepted as a part of the undergraduate curriculum; certain institutions introduced graduate instruction and so became universities; and institutions supported by public funds appeared on the academic scene. By 1900 the system of higher education in this country had begun to take on the pattern that we know today.

In any review of this country's academic establishment it is important to keep in mind that the establishment is by no means a static one. During the past 60 years many changes have taken place. The notes to be presented in this memorandum will be limited to a discussion of the present status of undergraduate institutions which are responsible for the basic training of U.S. scientists.

SOURCES OF INFORMATION

The data to be presented in this memorandum come from a study by the writer, entitled "Education and Training of Chemists in the U.S.A." which was published as a four-part series this past spring in Chemical and Engineering News (C. & E. N.). The published data apply specifically to the 884 institutions that awarded a bachelor's degree in chemistry in 1962. However, since these same institutions are the ones that educate and train this country's other scientists (mathematicians, physicists, biologists, etc.), the picture derived for the training of chemists must be generally valid for the training of all scientists.

A further advantage in basing this presentation on information available for chemists is that the American Chemical Society has a committee on professional training which has the responsibility of identifying undergraduate institutions that have the resources (staff, curriculum, library, laboratories, and equipment) deemed desirable for the training of chemists. It is not unreasonable to assume that most of the institutions having resources adequate for the training of chemists also have the necessary resources for the training of other scientists. Accordingly, we shall hereafter refer to those institutions that satisfy the ACS criteria as "strong" and those that do not as "weak," intending these adjectives to refer only to the resources of an institution with respect to training in science.

CONTROL OF INSTITUTION

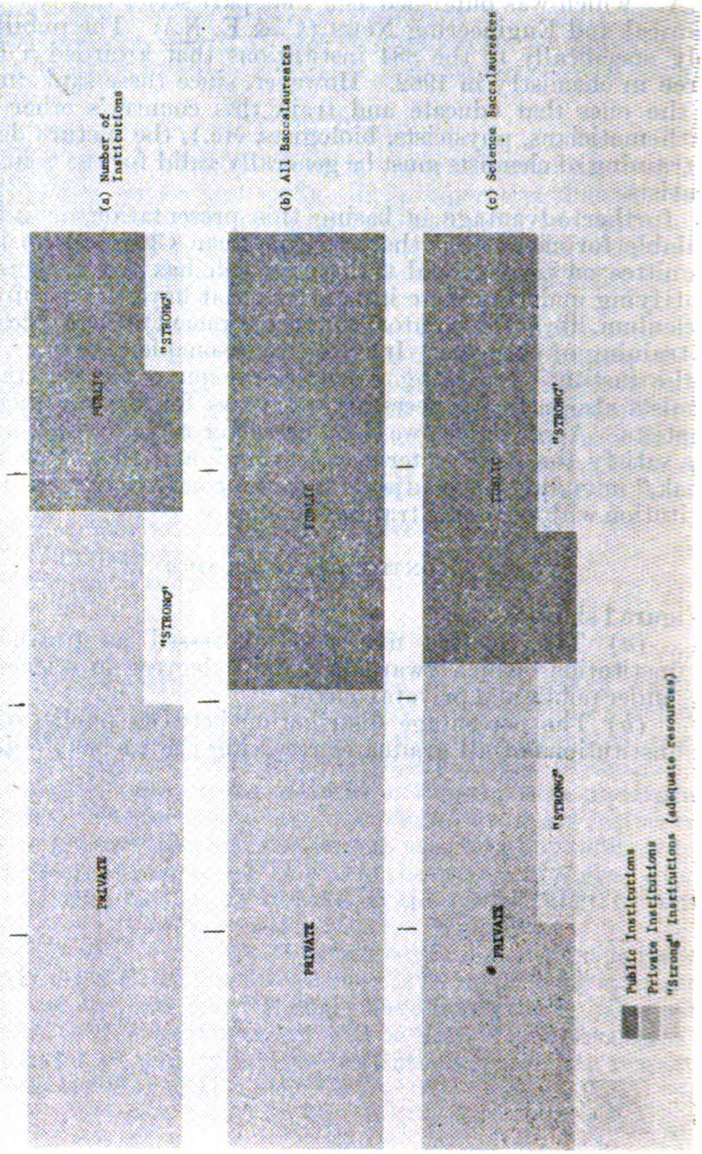
Figure 1 shows:

(*a*) The relative numbers (expressed as percentages) of institutions which award bachelor's degrees in science that are under public and private control.

(*b*) The percentage distribution between public and private institutions of all graduates receiving the bachelor's degree.

Fig. 1

Percentage Distribution, According to Control (Public and Private), of U.S. Colleges and Universities that Award Science Baccalaureates.



(*c*) The percentage distribution between public and private institutions of those students who were awarded the bachelor's degree in science (chemistry).

The data in figure 1 show clearly that, in spite of the tremendous growth of public institutions, the privately controlled institutions are responsible for about one-half of all bachelor's degrees and for slightly more than one-half of bachelor's degrees in science (chemistry).

One cannot compare directly the resources of public and private institutions because, as is evident from figure 1, both categories include "strong" and "weak" institutions.

One can, however, make a useful comparison of "strong" and "weak" institutions, disregarding the type of control.

From figure 1 we see that about 40 percent of all science (chemistry) baccalaureates are awarded by the "weak" group of schools, public and private combined.

It has also been shown (C. & E.N. article) that the fraction of the science (chemistry) graduates that continue their education in graduate school is essentially the same for the "strong" and "weak" groups of colleges.

Figure 2 presents information for academic institutions compared on the basis of size ("large" equals total enrollment greater than 2,000; "small" equals total enrollment less than 2,000). It shows—

(*a*) The relative numbers (expressed as percentages) of large and small institutions.

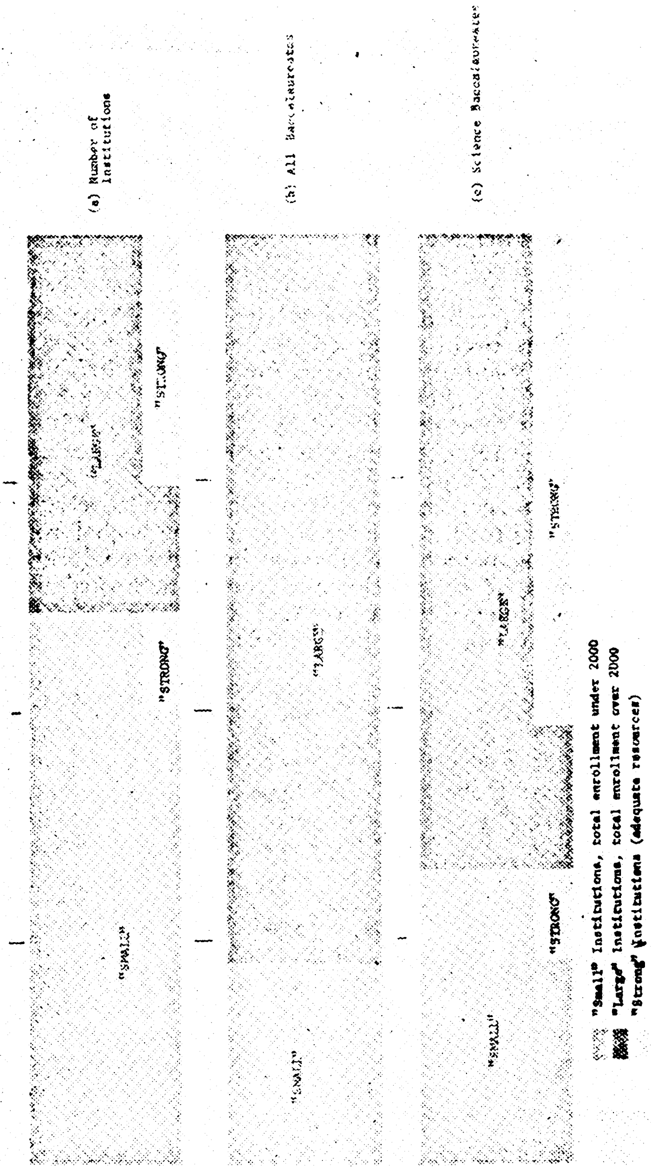
(*b*) The percentage distribution between large and small institutions of all graduates receiving the bachelor's degree.

(*c*) The percentage distribution between large and small institutions of those students who were awarded the bachelor's degree in science (chemistry).

As is at once apparent from figure 2:

Fig. 2

Percentage Distribution, According to Size of U. S. Colleges and Universities that Award Science Baccalaureates.



The percentage of small institutions is considerably greater than that of large institutions.

The percentage of all baccalaureates from large institutions overshadows that from small institutions.

The percentage of science (chemistry) baccalaureates from large institutions is just about double that from small institutions. It is to be noted, however, that the proportion of all graduates who take their degrees with a major in science is significantly greater for the small institutions than for the large institutions.

With regard to "strong" and "weak" institutions in relation to their size, figure 2 shows:

That a high percentage (66 percent) of the large institutions are in the "strong" class. This would seem to be a natural consequence of the fact that most large institutions are universities and one would expect them to be "strong."

That only a small percentage (17 percent) of the small schools are in the "strong" class.

That the small "weak" institutions provide about twice as many science (chemistry) graduates as the large "weak" institutions.

FURTHER NOTE ON RESOURCES OF U.S. COLLEGES AND UNIVERSITIES

In the preceding two sections, reference has been made to "strong" and "weak" institutions as determined by criteria set for college chemistry instruction. It is reasonable to suppose that the basic cause of the difference between "strong" and "weak" institutions is a difference in financial resources. In this section, attention will be directed to some dollar figures that lend strong support to this supposition.

The per-student educational budget of an institution can be calculated from published figures for "educational and general" expenses and the total enrollment of the institution. The per-student budget figures computed in this way cover an extraordinary range, from about $300 to $6,000, for both public and private institutions. A partial analysis of these per-student budget figures is presented in the following tabulation which shows the median figure for the specified categories.

Median per-student educational budget

	Private institutions	Public institutions
Classification of institution:		
Strong	$1,400-$1,600	$1,200-$1,400
Weak	800- 1,000	600- 800

This analysis could be improved if it were possible, in the case of universities, to distinguish between costs for undergraduate and graduate instruction. This is practically impossible and, therefore, the per-student budget figures for universities are the average for all students, undergraduate and graduate alike. Although it is recognized that the per-student budget figures for colleges and universities are not strictly comparable, they have been treated as if they are on the same basis in deriving the median figures given in the tabulation.

SUMMARY AND RECOMMENDATIONS

Summary

The salient points made in this memorandum, with certain supplementary comments, are the following:

> The small undergraduate college is still a significant part of the U.S. educational system. The continued strength of the small institution rests on two factors: the special character and appeal which derives from the small size of the institution; and the location of the institution near the home of the student. The fact that the great majority of these small colleges are privately supported and controlled attests to the value placed on them.
>
> Only a small percentage of these small institutions have the staff, facilities, and the instructional equipment deemed desirable for the best instruction in science.
>
> Yet, in spite of this handicap, the small undergraduate college is still the source of perhaps 35 to 40 percent of our young scientists—at all levels of training.
>
> Furthermore, the percentage of all baccalaureates who choose science as a career is apparently greater for the small colleges than for large institutions.

Recommendations

If, as a matter of national policy, this country must now plan for the education and training of increasing numbers of scientists, the facts presented in this memorandum point clearly to the importance of helping the small institutions strengthen their offerings in science. A program designed to help the small institutions should direct its attention, first, to the teaching staff, and second, to facilities and equipment. Were the staff and facilities of small institutions strengthened, even to a small degree, certain important consequences can be anticipated:

> (1) The science majors now attending these small institutions would receive better training.
>
> (2) The small institutions would be able to attract and hold young scientists who now find the prospect of teaching in such institutions unattractive in comparison to the opportunities open to them in the research laboratories of industry, government, or universities.
>
> (3) In the long run, the fraction of students in a small institution who became interested in science would almost certainly increase.

With respect to the kind of support that would be of significant benefit to science teachers in small "weak" colleges the following suggestion is offered:

> The establishment by a Federal agency of a program under which grants equal to 15 percent of annual academic salary can be made to science faculty members in purely undergraduate, 4-year institutions to permit and encourage these faculty members to devote 2 months of their summer vacation period full time to study and work related to their responsibilities as college teachers. For want of a better name we shall refer to this program as the faculty support program.
>
> Grants made under the faculty support program should not be prejudicial to a recipient's making application for support

for other purposes which can also contribute to his qualifications as a teacher; e.g., support for research projects (with or without students), summer institutes, travel to meetings, etc. It is to be understood, of course, that only support supplementary to the salary grant could be requested; that is, the total compensation which a teacher would receive for a summer period would be the 15 percent of his normal academic salary.

Administration of the suggested program could be carried out most simply by leaving it to the administration of a college to request support for its faculty members, a step which would give the administration some responsibility for the operation of the program locally. The paperwork involved in the "request" and the unavoidable "report" should be kept to a minimum, perhaps less than one page per faculty participant.

The foregoing plan should provide both the necessary incentive and flexibility. Its last element is essential because the needs of college teachers are manifold, depending as they do in each individual case on the teacher's background and the history of his department. It is inconceivable that any agency, desirous of helping teachers in small colleges, could design and establish all the programs which would be required to meet the individual needs.

The annual cost of the proposed faculty support program would be well under 1 percent of the annual support given by Federal agencies to scientific research.

STATEMENT SUBMITTED TO THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT OF THE COMMITTEE ON SCIENCE AND ASTRONAUTICS, HOUSE OF REPRESENTATIVES, BY THEODORE R. SIZER, DEAN, HARVARD UNIVERSITY, GRADUATE SCHOOL OF EDUCATION

Over the last 10 years, tremendous strides have been made in the improvement of mathematics and science instruction in secondary schools. National curriculums have been developed. Institutes for experienced teachers have been established. Substantial sums have been made available for laboratory equipment and instructional aids. Salaries of teachers have been increased.

There are two areas in which comparable advances have not been made: (1) graduates of liberal arts colleges have not been attracted to careers in science or mathematics education in anywhere near the numbers needed; (2) in general, the quality of undergraduate programs designed to prepare teachers of mathematics and science leaves much to be desired.

Those universities which offer a fifth-year program of preparation for teaching mathematics and science in the schools (master of arts in teaching programs) have been able to attract a number of graduates of strong liberal arts colleges. These young people typically have completed their undergraduate work with distinction in a demanding program of mathematics and science; they possess intellectual power comparable to those electing other professional endeavors; they enter teaching with a high degree of commitment and enthusiasm. Though few in number, their impact on the schools has been significant. A dramatic increase in the number of students entering teaching with such qualifications could be made. The crucial need is a program of fellowships which would provide financial support for students during their year of preparation for teaching. Harvard's success to date in attracting highly talented students in mathematics and science is in large part due to grants for scholarships from the Sloan Foundation. These funds are no longer available. Other universities are in a similar situation.

With reference to the second problem, undergraduate preparation of mathematics and science teachers, it is clear that radical changes must be made in the conditions which affect the quality of these programs. Standards of admission must be raised; quality of course offerings must be improved; the design of the programs must be reexamined. This is easier said than done. There are over 1,000 institutions of higher education offering undergraduate programs.[1] Even

[1] Though there are over 1,000 institutions engaged in teacher training, we estimate that only 25 percent produce 70 percent of the 20,000 undergraduates licensed to teach mathematics or science in the secondary schools each year. Staffing 250 institutions is a feasible objective. For example, if the universities could graduate 80 doctoral candidates in mathematics education each year (4 in each of 20 universities), in 3 years time we could add 1 highly trained person to each of the 250 institutions which prepare the vast majority of teachers.

if there were agencies—government or private—empowered to mandate change (and there aren't), little change would take place. The real changes must come from within each institution. More specifically, improvements will depend on the quality of mind and the quality of preparation of the member or members of the faculty in such institutions who are directly concerned with mathematics or science education.

The extent to which new staff members possess these qualities in sufficient measure depends ultimately on the universities which prepare instructors in these fields. Such universities must insist on the most demanding admission standards and offer a highly sophisticated program of training both in mathematics (or science) and in pedagogical matters. To recruit the kind of doctoral student who can meet these standards, the universities must have fellowship funds.

In the midfifties, the National Science Foundation launched a bold program of yearlong and summer institutes to increase the competence of experienced high school teachers of mathematics and science. By any gage, this has been an extremely successful program. However, this effort was not aimed at opening up fresh sources of highly talented teachers for the schools. Nor was it directed at the even more difficult task of preparing instructors for the teacher training institutions. The cost of those two endeavors would be relatively modest compared to the outlays needed to upgrade the existing crops of teachers. Indeed, it is not inconceivable that success in the two efforts suggested here could make possible a tapering off of institute programs in the next few years. We strongly urge, therefore, that the National Science Foundation extend its efforts in mathematics and science education to include fellowship programs (1) for graduates of liberal arts colleges who wish to prepare for teaching in the schools, and (2) for doctoral students who are looking toward a career in the teacher-preparing institutions.

STATEMENTS OF CERTAIN MEMBERS OF THE NATIONAL SCIENCE BOARD

AUGUST 16, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development,
House of Representatives, Washington, D.C.

MY DEAR MR. DADDARIO: This letter contains my answers to some of the questions forwarded to Dr. Eric Walker by the Subcommittee on Science, Research, and Development. Since Dr. Walker felt that the subcommittee might be interested in the views of other board members than himself, he has provided us with copies of the questions and has suggested that we reply individually. In order to keep this letter as brief as possible, I am omitting a number of the questions because they involve matters of fact which can best be dealt with in other ways.

1. The National Science Board was characterized by Dr. Waterman in his testimony as "a unique body for dealing with policy matters," and he advocated more use of it within the executive branch by such agencies as the Office of Science and Technology, the Federal Council for Science and Technology and the President's Science Advisory Committee. What is your comment?

I agree with Dr. Waterman that the National Science Board is "a unique body for dealing with policy matters." So far as I know, however, it has never been seriously consulted on matters of scientific policy other than those involved with the operations of the Foundation itself. It might be worthwhile to experiment with using the Board more extensively in setting the national policy toward science. Some of the reasons for feeling that the Board may have special competence in this area are the following:

(*a*) The Board is broadly representative and contains "working scientists," scientific administrators, representatives of the scientifically based professions, and men of affairs.

(*b*) It appears to be rather more detached from specific missions or specialized fields than most other Government boards and committees dealing with scientific matters.

(*c*) It has access to a large and competent staff covering all of basic and much of applied science. Steps are being taken to increase the number and quality of the staff dealing specifically with the gathering of data about science and the formulation of policy.

2. As you know, Reorganization Plan No. 5 would abolish the statutory divisional committees. In his appearance before the Executive and Legislative Reorganization Subcommittee, Dr. Haworth stated that the number of Divisional Committees has proved cumbersome; and he cited as an example that under the National Science Foundation Act three committees were now required to deal with scientific personnel and education matters, whereas one committee was all that was necessary.

(*a*) Rather than abolish all eight divisional committees, why didn't the National Science Foundation just reorganize the three committees concerned with scientific personnel and education?

(*b*) Have the divisional committees really fulfilled their original purpose?

It is my understanding that the request for changing the status of the divisional committees was based largely on the desirability of making it possible for the Director to arrange these high level advisory groups in as useful a way as possible in relation to the organization of the full-time staff of the Foundation. Since the latter must necessarily change with changing needs, it would be unfortunate if the advisory groups related to it could not be changed at the same time.

4. What science policy function does the Board now serve that is not adequately provided for by existing organizational arrangements within the Executive Office of the President?

In practice there is necessarily a good deal of overlap between the National Science Board and the Executive Office of the President. In theory one may say that the President's office is primarily concerned with seeing to it that the scientific establishment is properly prepared for and responsive to specific national needs. Indeed, a good part of the present activities in the executive office arose

from the acute consciousness of the need for expert advice in science as related to National Defense and the exploration of outer space.

On the other hand, the National Science Board was established to represent the needs of science as conceived by the scientific community itself and by the civilian public.

Obviously, there can be no sharp separation between what is "good for science" and what is "good for the Nation." Nor can one be very clear about a distinction between "national needs" and the needs of the general public. Nevertheless, I believe that the shades of emphasis represented by these various terms should be given separate consideration in the formulation of policy and that the present division of responsiiblity between the National Science Board and the Executive Office is good and useful.

5. In your judgment, should NSF be given greater operational authority? Why, or why not?

It is my belief that the NSF has sufficient operational authority if by this is meant the authority to operate programs such as that dealing with research in the Antarctic, atmospheric research, and so on. It is more difficult to say whether the NSF should exercise this authority more fully, either by taking a greater management role in programs now under contract or in developing new operations. There is some question whether the Foundation is adequately staffed and organized for discharging some of the management responsibilities it already has. Fortunately, the problem is recognized within the Foundation and is under active study.

My own views on whether the operational role should be expanded are not completely formed, but I would incline in that direction for the following reasons:

(*a*) Certain types of research must be conducted on a national or international basis and with a considerable degree of coordination. Universities and conventional research institutes have not proven themselves fully competent instruments for investigations of this character. On the other hand, some private foundations have had striking successes. Most notable, perhaps, is the Rockefeller Foundation with its worldwide study of the epidemiology of certain important diseases—hookworm, yellow fever, and malaria—and its more recent work on improving food production in underdeveloped countries. The current success of the antarctic program, and the promise of the National Laboratories established by the NSF suggest that it can do what is necessary if it attacks a problem of this kind wholeheartedly.

(*b*) The presence of an active and successful operating program would increase the prestige and influence of the NSF in the scientific community generally. Furthermore, it would probably be helpful to the present staff to be more closely associated with a group of operating scientists.

(*c*) Experience has shown, especially perhaps at the NIH that the group of investigators in the institute laboratories provides an excellent source of personnel for the executive staff.

6. Do you consider the social sciences as positively within the purview of the Foundation? How does the Board define NSF's role for support of research in the social sciences? Is this role likely to increase or decrease?

I do consider the social sciences as positively within the purview of the Foundation. So far the Board has perhaps given special emphasis to those aspects of social science which can be most clearly related to the more conventional natural sciences, but the definition has been steadily broadened as experience has been gained. I would expect the Foundation's role to increase depending in part on what is done by other Government agencies with responsibilities in this area.

7. The budget of NSF has increased from about $15 to $480 million, and some witnesses have suggested that it become as large as $1 billion in the foreseeable future. With this tremendous growth, is it in the best interest of science to maintain this dual (Board and Director) authority over NSF, or would it perhaps be better to have the Director solely responsible for the management and operation of the Foundation, and have the Board serve in an advisory capacity to the Director (a National Science Advisory Board)?

The present sharing of authority between the Board and the Director is certainly unusual and for various reasons seems unlikely to survive for very long. In its original form, the NSF was, of course, modeled closely on the pattern which had been found successful in the major private foundations. As matters have developed, however, several crucial differences between a private and a Government foundation have come into clear view. The first is that in a private foundation the Board holds title to the assets, and controls both the income and the expenditures. In a public foundation the income results from a series of decisions in the executive and legislative branches.

The second difference is that no single private foundation is large enough to have a controlling effect on the direction of science. The National Science Foundation is not only large enough, it is in fact charged with making decisions and allocations which determine major shifts in direction not only of scientific research but a large part of scientific education as well.

It has proven impossible for the executive and legislative branches of Government to delegate decisions of this magnitude completely to an independent board. The legislation of 1960 making the Director more immediately responsible to the President rather than only to the Board clarified the situation of the Director but increased the ambiguity of the Board's position. Although I have not discussed the matter with enough other people to be sure of my own position, I am beginning to feel—to use the words of your question—that. "it would perhaps be better to have the Director solely responsible for the management and operation of the Foundation, and have the Board serve in an advisory capacity to the Director." Certainly, such a change would result in a clearer more understandable flow of decision making. It might also make it possible for the members of the Board to speak with more freedom about the needs of the NSF to the general public, and at legislative or budgetary hearings.

In my judgment, it would be essential to make sure that the advice of the Board be regularly sought both on questions of policy and on a significant range of day-to-day operations, and it is equally important that the Board continue to feel that its advice is taken seriously both inside and outside the Foundation. Otherwise, it will be difficult to attract people of appropriate calibre to membership on the Board or command their attention once they are there.

Whaever one may feel about the exact legal status of the Board, there can be no doubt of the importance of having such a group of individuals representing both the scientific community and the general public, closely coupled with the policymaking process.

8. What is the Board's fundamental policy with respect to NSF fellowships and grants to universities and colleges? Is your policy aimed primarily at supporting scientific research on the campus, and secondarily at the education of students and the training of science teachers; or is it vice versa?

I doubt if it is very useful to try to draw a distinction between scientific research and scientific education at the university level.

9. What is the Board's view regarding the stationary level of the NSF staff over several years when its own funding and that of Government has sharply grown? Is the staff assistance provided for the Board satisfactory?

I believe that the number and quality of the staff is one of the most important problems facing the Foundation. The present staff, especially at the higher levels, strikes me as very good in quality, but it is seriously overworked. Recent improvements in salaries have helped to retain staff, but the national pool of people who understand both science and administration is very small. Paradoxically, the success of the NSF and the NIH in establishing satisfactory working conditions for scientists in universities and research institutes makes it increasingly difficult to attract the right people into Government office. Everything possible should be done to enable the Foundation to attract more able people. Salaries are important, but perhaps most important of all is the assurance that anyone who joins the staff will have a real opportunity to achieve what he wants for the advancement of science.

10. In what areas should NSF exercise its existing authority further? What new roles do you foresee for the Foundation over the next 10 years and what new authority seems warranted, as for example in areas of applied research and engineering?

I would like to see the Foundation play a more significant role in the international development of science. At least four different roles may be distinguished, in all of which the Foundation already has some experience.

(*a*) The support of international scientific communication—meetings, travel of individual scientists, and support of international programs of investigation, such as the International Geophysical Year. These activities are well understood and supported.

(*b*) Participation in the national program of aid to underdeveloped countries. The Foundation's capability has been demonstrated in a few pilot programs of technical assistance and scientific education, but in spite of marked success it has not been encouraged to develop a program of sufficient size to have real impact. Since technical assistance is not part of the National Science Foundation's regular mission, it might be most appropriately financed by contracts with the AID organization.

(*c*) Support of science in other advanced countries as part of its mission to look after the welfare of science in general. The Foundation has long had a small program of this kind and the principle is well established. Other Government agencies also support investigations in foreign laboratories. In the judgment of many people who have looked into the matter, it appears that if the United States is to have a program of support for science overseas it would be appropriate for the National Science Foundation to play a more significant role. The present situation in which some branches of the Department of Defense are more conspicuous than our civilian agencies in the support of basic science abroad is hard for observers both here and in other countries to understand.

(*d*) Support of science in countries of intermediate status. There is likely to be an increasing number of countries which have passed the first stage of development and no longer need extensive economic assistance, but which have not yet reached fully satisfactory standards in scientific research and higher education. The National Science Foundation is ideally fitted to aid such countries in the establishment of such scientific institutions. Such a program might not have immediate impact but in the long run it would be almost sure to return fine results in the advancement of science and the improvement of international understanding.

The present staff for international work, though excellent in quality, is wholly inadequate in numbers for any but the first of the four activities outlined. A considerable increase would have to be authorized if it were decided to expand in any of the suggested directions.

Others are better qualified than I to discuss the role of the National Science Foundation in relation to applied science, especially engineering. My personal views are conservative. In my opinion, the Foundation has a big job to do in looking after the health of basic science, and it should scrutinize very carefully any suggestion that it take on responsibility for the solution of specific practical problems, such as, for example, the control of air traffic, the desalting of water, or the breeding of more productive strains of wheat. Such problems may more appropriately be attacked with help from the relevant Government agencies—the Departments of Commerce, Interior, and Agriculture, for example. Not only is the specific goal more likely to be kept clearly in mind than it would be if the work were wholly supported by an agency with a more general mission, it is also an excellent thing for any agency with a practical mission to have close contact with an active research program.

Finally, it should be pointed out that National Science Foundation already has a far more active program in the support of engineering activities, both in research and teaching as these are found in universities, than is generally recognized. This program should be continued and expanded as opportunity offers.

13. Are too many Federal agencies today involved in supporting basic science grants and science education? Might not the Foundation assume a more central, or perhaps an exclusive role in this regard?

There are good reasons for encouraging other Federal agencies to support basic scientific investigations and education. Science benefits from multiple support, and conversely it is healthy for most Government agencies to have an active contact with the academic world. The desirability of more coordination and exchange of information among Government agencies is increasingly recognized, and the National Science Foundation has, fortunately, shown a willingness to play a more central role. This tendency should be encouraged.

15. A dropout problem exists for students of science and engineering as well as other subjects. What should the National Science Foundation do to study the reasons for dropouts in secondary schools and colleges? Should it take a mission interest and actively seek to interest investigators in such studies, or should it wait and hope that some scientists will become interested on their own and submit suitable proposals?

The dropout problem as it exists at all levels is an appropriate subject to study with the techniques of social science. The Social Science Division of the National Science Foundation might well search for opportunities to support such investigations.

16. Should the Foundation's national laboratories and, for that matter, the large laboratories of other departments, such as the AEC's Argonne National Laboratory, be treated as permanent national scientific assets to be indefinitely maintained, or should their continued existence depend upon the current vitality and importance of the fields of science in which they excel? Should they have an indefinite mortgage upon future resources for science? If so, what should be their role as efforts and attention of scientists change to new fields?

Support for the national laboratories should, of course, be conditioned by the vitality and importance of the fields in which they excel. It should be recognized, however, that most of the existing laboratories were established in fields about which relatively little is understood and which give promise of producing important information for a long time. They should receive support on the assumption that such support will be needed on an expanding scale for many years.

17. What is your opinion about the proposal that annual funding for National Science Foundation supported basic research be increased by 15 percent annually to accommodate entry of new scientists into independent research and to cover the increased cost of equipment? Do you see graduate schools capable of accommodating a continually growing graduate student body in the sciences? Can the undergraduate colleges be expected to produce more students each year for graduate study in the sciences?

The proposal that the annual funding of the National Science Foundation for the support of basic research increase by 15 percent annually seems to me to have been based on accurate information and sound judgment as applied to the next 5 or 10 years. The question of how long undergraduate colleges and universities can go on producing an increasing number of scientists cannot be precisely answered, but it would appear that we are still considerably short of our maximum potential.

Thank you for giving me this opportunity to comment on this very interesting set of questions. Whether or not the subcommittee finds anything helpful in the answers, I am sure I will be a better Board member for having had to think about them.

Very truly yours,

ROBERT S. MORISON, M.D.,
Member of National Science Board, Director of the Division of Biological Sciences, Cornell University, Ithaca, N.Y.

RICE UNIVERSITY,
Houston, Tex., August 16, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, House Committee on Science and Astronautics, Washington, D.C.

DEAR MR. DADDARIO: Dr. Eric Walker, Chairman of the National Science Board, has sent to the members of the Board copies of your letter of August 9 enclosing the 19 questions your committee submitted to him after his testimony on July 27. Since it appeared impracticable to convene the Board, or to get a significant consensus, he suggested that some of us might be willing to write you our personal views on some of the questions.

I must especially emphasize that the views expressed below are mine alone, but they are views based on almost 12 years as a member of this Board. The comments are numbered to correspond with your questions to Dr. Walker.

1. The National Science Board is, I believe, unique in that a certain limited amount of authority is conferred on it by statute. It is possible that this authority has not been exercised as vigorously as might have been, but in any case such authority can extend only to the activities of the National Science Foundation itself. The Board can influence other agencies only through persuasion or through the Office of the President.

2. The rather rigid connection between the system of divisional committees and the internal organization of the Foundation staff, although provided in the original act, possibly went somewhat beyond the conscious intent of the authors. The suggested reorganization provides a flexibility such that the divisional committee structure, as well as the staff organization, can be rapidly adjusted to the changing obligations of the Foundation.

3. I doubt if the Foundation should have greater operational authority. Its peculiar function, and the area in which I believe it has been the most valuable, is in the support of small-scale basic research in a wide variety of places and institutions.

I can remember that during the 1930's the Government operated scientific laboratories, at least in the physical sciences, were not highly regarded by the scientific community in the field of basic research. Among the reasons for this was that, in the field of basic research, originality is more important than experience. A research laboratory starts out with an enthusiastic staff and they all grow old together. In a university, the continuing influx of new students can produce a steady stream of new ideas. Most of them are bad, but they can

be evaluated by the senior people. Government and industrial laboratories are now attempting to provide similar conditions, but it is not easy.

During the Second World War the idea of contract research in universities was developed to remedy the deficiencies felt in the Government laboratories. At the end of the war, efforts were made to perpetuate the scheme through the Office of Naval Research, the Research and Development Board, and then through the National Science Foundation. The Foundation has been most effective in this aspect of its work.

It must be emphasized again, that the above comments refer only to basic research. Work in applied research and engineering may very well be done in institutions devoted to such research and engineering only.

7. I believe it is important that the National Science Board retain its present authority. One reason is that it gives the members of the Board a feeling of greater responsibility than would a purely advisory capacity. It permits the President to appoint members of greater stature and it gives the scientific community a feeling that the Board, which to some extent represents them, can have some significant influence upon the policies, at least of the Foundation itself.

9. The staff of the Foundation is quite small when one considers the amount of money they must disburse, in relatively small packages.

On the other hand, the National Science Board has no professional staff at all. The Director has always been most helpful in providing members of his staff to do work for the Board, but the fact that their permanent assignments are on the Director's staff makes it difficult for points of view to be developed apart from those of the Director. Since the two Directors of the Foundation have been men for whom the Board has had the greatest respect, relations have been most amicable, but possible alternative policies may not always have come to the attention of the Board but have been resolved in the staff instead.

In conclusion may I express the gratitude which I feel as a member of the Board for the effective way in which your committee is studying our operations.

Very truly yours,

W. V. HOUSTON,
Member of the National Science Board.

NATIONAL SCIENCE FOUNDATION,
NATIONAL SCIENCE BOARD,
Washington, D.C., August 27, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. DADDARIO: Dr. Eric A. Walker, Chairman of the National Science Board, has invited the Board to contribute statements concerning the list of questions, addressed to him, in your letter of August 9, 1965. As he noted in his letter to us, several questions are essentially matters of fact to which quite specific factual replies should be supplied. It is my understanding that Dr. Walker will provide these in good course. In the statements below, I have attempted to summarize my own reaction to several of the cogent questions which you have put to Dr. Walker.

Question 1. The President's Science Advisory Committee is appointed with the substantive nature of various aspects of science and their specific relationship to the diverse but highly specific missions of many Federal agencies in view. Because of the general flow of information to PSAC and its clear relationship to the special assistant to the President for science and technology, this committee attempts to remain cognizant of the total commitment of the Federal Establishment in science and technology, the manner in which the funds for these purposes are distributed through the specific agency budgets, the impact of such techniques of funding on universities, the civilian economy, and the Federal Establishment. These are broad charges indeed and the part-time PSAC finds it a full-time task to gather the necessary comprehensive view which would permit a firm grasp of the many relationships involved. As you know, a substantial portion of PSAC is spending the summer at Woods Hole grappling with just these problems.

In contrast, the National Science Board represents a wider cross-section of background an dexperience than does PSAC. Accordingly, it is in better position to recognize the impact on, and contributions to, Federal policies for science on the part of industrial organizations, small liberal arts colleges, the great uni-

versities, and the scientific community generally. It is precisely because of this diverse composition that the Board can serve the National Science Foundation well in a policymaking role. On the other hand, the Board long ago adjured the larger role for national science policymaking originally envisioned for it in the act. In retrospect, this early position of the Board was a wise decision and the original reasoning retains its validity. No board which exists in a unique relationship to a single operating agency should be asked also to serve in a broader policymaking capacity. Such a broader policymaking organization is indeed required and it is this role which is presently assigned to PSAC which can serve in this capacity by virtue of the very fact that it bears no specific responsibility for any specific agency of Government.

PSAC–OST and the National Science Board are not in conflict nor do they overlap significantly in function. Rather can they maintain a useful dialog. As the Board and Director with their responsibilities and concern for basic science establish the role of the Foundation in support of specific scientific disciplines, it is to PSAC–OST that this information is communicated so that the total Federal program may be shaped and balanced.

Accordingly, I endorse the statement made by Dr. Waterman with respect to the Board.

Question 2. Those of us who are "alumni" of the divisionel committees of the Foundation are quite divided in our views with respect to the usefulness of the divisional committees. The act placed upon the Board responsibility for policymaking as well as the direct awarding of grants, etc. The program panels are composed of experts in specific scientific disciplines and are in best position to render judgment on the scientific merits of proposals which come to the Foundation. But no really specific role was created for divisional committees. Some of the latter have felt that they contributed significantly to the vigor and integrity of the Foundation's programing; others have felt that their committees were essentially useless. In retrospect one may wonder as to whether these committees have been adequately exploited on behalf of the Foundation.

In the most significant sense, the divisional committees should have been the means of assuring the coupling between the scientific community and the Foundation, a problem to which Dr. Walker referred in his testimony. To some degree this has surely been the case. But it now seems to me that these committees were not asked to work sufficiently hard. For example, it might well have been these committees which undertook the task of generating the studies of science, by particular fields and discipline, which have more recently been undertaken by specific subcommittees of the Committee on Science and Public Policy of the National Academy of Sciences. Perhaps it should have been these committees which should have signaled in sufficient time the needs of astronomy or the fact that, for lack of a natural home among the mission-oriented agencies of Government, the science of chemistry has been supported in a fashion which is not commensurate with the role of this science in the national economy or its significance in health, agriculture, or defense.

I do not think the question of the precise number or composition of the divisional committees is a significant issue in the life of the Foundation. However, the role of these divisional committees is a significant issue and that role should be more clearly defined at an early date.

Question 4. It is the function of the Board to generate policy with respect to the operations of the National Science Foundation—not for the totality of science or technology in the Federal Establishment. To be sure, in order to do so effectively, the Board must be quite cognizant of the programs of other agencies. But the Board is in far better position than is PSAC, for example, to estimate the need for and magnitude of the program of course content improvement or the magnitude of Foundation support of molecular biology. At the same time, the Board serves in a general sense as overseer of the national laboratories and programs which have become the responsibility of the Foundation. In contrast, while PSAC must concern itself with these problems in the most general way, its involvement with various aspects of the Defense Establishment, civilian technology, high energy physics, earthquake prediction, national manpower needs, etc., is of such intensive nature that the details of policy for the National Science Foundation—even though it be a one-half-billion-dollar-a-year enterprise—are simply beyond the capabilities of the PSAC. And there is no other external committee anywhere in Government which could accept the functions of the National Science Board.

Clearly there is required a hierarchy of decision and policymaking. At each level, scientists and representatives of the public, external to the Federal Establishment, can usefully contribute. These various layers are not necessarily

subservient to those above; rather, as one proceeds up the ladder, one is concerned with problems of ever-broadening nature. Although this system may not be perfect, it is working remarkably effectively.

Question 5. In my years of service on the National Science Board I have become ambivalent with respect to the desirability of a broadened operational authority for the National Science Foundation. Conceived entirely as a granting agency, by virtue of its very responsibilities for insuring the vitality and integrity of the entire national effort in basic research, the Foundation has accepted responsibility for a series of what may be termed "wholly owned subsidiaries." These include the Kitt Peak National Observatory, the National Radio Astronomy Observatory, the National Center for Atmospheric Research, and the Mohole project as well as programs in the Arctic and Antarctic. In each instance, the Foundation has entered into a contractual relationship with another organization, usually a synthetic corporation which is a consortium of universities. Nevertheless, the rest of Government, including the Congress, looks to the Foundation for the policies which shall obtain and the conduct of these national facilities and programs. And it is the Foundation and its Board which, together with congressional approbation, establishes the level of funding of each such operation. The Foundation has responsibility, yet the current arrangements deprive it of authority for the actual management of these facilities. One might readily suggest that, were each laboratory and facility directed by a management group which in turn is directly responsible to the Director of the Foundation, the Foundation and hence the Congress and executive branches could be more certainly assured that the original purposes which underlay the creation of these facilities would continue to be served. The necessary scientific advice with respect to program details could continue to derive from an external scientific advisory body for each such facility. But in practice the current, seemingly contrived, arrangements have worked quite adequately. And the scientists and universities have a sense of "belonging" to Kitt Peak, NCAR, or Greenbank which they would certainly otherwise lack. The fiscal control exerted by the Foundation appears sufficient as a means of assuring that the Government's purpose in creating these laboratories is safeguarded.

Accordingly, although there may one day appear some opportunity which could not be grasped for lack of direct operating authority, there seems to be no compelling requirement for such authority today.

Question 6. I share the view of the Board that the social sciences quite definitely fall within the purview of this Foundation. However, the Foundation has taken a restriced view of what constitutes social science. This view has served to protect the Foundation from involvements in controversial issues since it relates the Foundation to quantifiable aspects of the social sciences and divorces the Foundation from matters which might be called opinion.

But it is increasingly clear that man has learned to develop science and technology with greater skill than he has learned to manage human interrelationships either at the individual or societal level. Since much of the social ferment of our time is a consequence of the scientific and technological revolution, it certainly behooves the Foundation to be increasingly aware of the social implications of science as a very minimum of its interest in research and education in the social sciences. In the long run, however, this is clearly insufficient. Hence, I cannot help but feel that the role of the Foundation in the development and support of social sciences in our country will expand significantly in the future.

Question 7. My views with respect to the relationship between the Board and the Foundation were offered in an earlier letter addressed to Dr. Haworth in commentary upon the testimony of Dr. Walker. Increasingly, the role of the Board must be restricted to the formulation of policy and advice in only the larger, overall matters which come before the Foundation. I share the view that the budget of the Foundation should continue to grow rapidly for the next 10 years and would be happy to document this on another occasion. But at that level of activity, a part-time Board cannot expect to accept responsibility for the award of grants. It must be kept informed with respect to grant awards to that it can remain in as intimate relation to the affairs of the Foundation as possible. Policy in the abstract is without meaning. The Board must decreasingly serve as a monitor over the actual granting process yet it must remain highly informed with respect to the grants program so as to be aware of problems, of changes in the role of the Foundation in our society, of changes in the nature of requests brought to the Foundation, of changes in the practices of universities, of the needs of individual scientists, of scientific disciplines, of research and educational institutions, etc.

In point of fact, however, I hold no brief for the legal arrangements whereby this is accomplished. Whether the Board is legally stripped of its authority and placed in a strictly advisory policymaking role, or whether it surrenders its authority by delegation to the Director as has been increasingly the practice in the last several years, is to me a matter of little concern. As long as the appointments to the Board continue to be prestigious scientists, university administrators, and public figures, I am confident that the Director neither would nor could ignore firm recommendations to him from such a body. On the whole I prefer the status, de jure, of the Board to reflect its de facto role. And, increasingly, that role is advisory with respect to policy.

My concern in this regard derives only from the alarm which such a statutory change might arouse in the academic and scientific communities. But as long as the membership of the Board is appointed by the President and confirmed by the Senate, a practice which should be continued, this impact should be relatively slight.

In considering the role of the National Science Board, no analogy to the board of a corporation, university or private foundation is really valid. The board of a private foundation is answerable only to itself, within the broad constraints imposed by the law. But the National Science Foundation is responsible to the President and to the Congress. Its policies must be compatible with the total policy for science created by Congress and by the White House. It does not generate its own funds; these are sought from the Congress which is, in a real sense, the Board of Trustees of the Foundation. Accordingly, the legal position of the National Science Board is anomalous at best.

Question 9. I have no complaint with respect to the nature or magnitude of the staff assistants provided for the Board. But I should not that any knowlegeable individual who spends a significant amount of time at the Foundation soon becomes aware of the fact that, at the professional levels, the Foundation staff is diligent, dedicated, and overworked. The administrative costs in the operation of this Foundation represent a small fraction of those which could be expended by a private foundation similarly engaged.

Question 10. There is little doubt in my mind that there will be brought to the Foundation at frequent intervals suggestions for the development of new national facilities and programs in various areas of science. It is difficult to be certain which of these will offer sufficient promise as to warrant support viewed from this prospect.

I am insufficiently informed with respect to the nature of the engineering sciences to be certain of the lines which separate research in enginering science from the practice of engineering itself. I am completely comfortable with vigorous support of programs in engineering science by the Foundation and such authority already exists. In practice, support is given only to those projects addressed to problems of rather broad significance or application. Nor have I objection in principle to the direct support of engineering research per se. But such research must be directed to specific and practical goals. And it is difficult to imagine such engineering projects which do not appear to fall within the purview of some other agency of government and have direct relevance to its mission. Should the Department of Commerce or the NSF be concerned with improvemnts in techniques of surface transportation or of underground power transmission? Should Commerce or NSF concern itself with improved construction techniques for schools, residences, and offices? This line of reasoning seems to extend to all specific projects which have come to my attention and whereas I agree that in many instances the appropriate Government agency appear to have been laggard, my reaction is to suggest that such agencies be prodded to more vigorous pursuit of their missions rather than to have the National Science Foundation undertake their tasks. Nevertheless, I have no objection in principle and, indeed, rather favor a program of carefully selected engineering projects supported by the Foundation.

Question 13. The case against a monolithic Federal Department of Science has been made many times, and I can only associate myself with this position. Science and technology pervade all aspects of human affairs and accordingly are relevant to virtually all agencies of Government. To assure that each of these agencies pursues its own mission with maximum effectiveness, it is imperative that its own scientists remain in constant and mutually fruitful relationship with basic scientists and particularly those in the universities. By the same token, this network of relationships insures that there will be competent and knowledgeable scientists in the universities aware of the specific problems which confront their counterparts in the Federal agencies. Such relationships do not warp

the structure of freely undertaken university science. Rather does it awaken the university scientist to possibilities and opportunities of which he might otherwise have been totally unaware. At the same time, as he seeks funds in support of his own university-based endeavors, he is assured of more than one jury which will provide a hearing for his ideas. The current multiagency support of science, which is more a historical accident than the consequence of purposeful policy, has demonstrated its enormous strengths and should not be disturbed in principle unless there is a profound conviction that some other system will work as well.

On the other hand, it is also true that the National Science Foundation, quite uniquely, is the agency of Government created expressly to assure a balanced, vigorous national program in science in all of its aspects. Clearly this is not possible unless the Foundation has operating funds of sufficient magnitude to permit it to fulfill this heavy and broad responsibility. It is difficult to establish some magic formula by which one can calculate the exact fraction of the total Federal support of science which should be provided through the Foundation. Surely, 12 percent of the total support of university-based fundamental research is insufficient. Quite as surely, 75 percent of such support would be more than is required for the general purposes of the Foundation and would not permit the mission-oriented agencies the advantages which presently accrue to them in consequence of the current support pattern. Thus it would appear that perhaps 25 to 40 percent of the total Federal support of science should be made available through appropriations to the National Science Foundation. And this can be accomplished by a growth rate in the total Federal support of science which, for a few years, is skewed in favor of the appropriation for NSF.

Question 16. The national laboratories sponsored by the Foundation are great national assets. At least two of these, those at Kitt Peak and at Greenbank, were created to provide large and expensive, highly specialized scientific instrumentation which are then made available to the entire national community of scientists. These laboratories should remain in existence and be supported by the Foundation as long as their facilities make possible significant contributions to science. It is entirely conceivable that, one day, their expensive apparatus will be outmoded and that newer instrumentation providing yet greater capabilities will have been designed. Since, in all likelihood, such newer instrumentation will be costly and complex, it will again appear to be wise to place them in national laboratories. But should this projection fail to materialize, should current equipment not be succeeded by another generation of optical and radio telescopes and should the current instrumentation fall into disuse, the Foundation should not hesitate to close these laboratories.

The second portion of this question raises a problem which has deeply troubled many of us on the Board. The programs of these laboratories, as well as their equipage require considerable leadtime. Plans are made years in advance, contingent upon subsequent funding. At a time when the general grants program is not growing at the rate which had been hoped for by the scientific community, the Foundation staff and by the Board, the national laboratories represent a standing commitment against Foundation funds. These laboratories acquire the status of a preferred customer although this was clearly not the intention of the Board when preferred customer although this was clearly not the intention of the Board when the laboratories were created. To fail to fund the national laboratories at a level commensurate with their potential seems unwise, but no more so than is the failure to fund other meritorious projects which arise spontaneously within the scientific community and are brought to the Foundation for funding in the same year. The Foundation has no alternative but to fund the national laboratories at a level adequate to keep them in operation under such circumstances but even this concept has been extremely troublesome. This painful choice was apparent in the distribution of funds in the fiscal year 1964 and fiscal year 1965 budgets. Since the Board continues in its belief that optical astronomy, radio astronomy, and atmospheric science are among the most exciting of current scientific ventures, this decision was not quite as painful as otherwise it might have been.

Question 17. This series of questions can be rephrased as "How large should the national scientific enterprise be?" I know of no simple a priori grounds or set of first principles which permits a quantitative answer to this question. As a nation, we are aware that science and its offspring, technology, have remodeled our land, that they assure our defense, improve our health,

provide a sense of adventure, and each day make our lives more comfortable if not happier.

The magnitude of the scientific enterprise which has made this possible has, to be sure, reflected our national purpose. But more simply, the level of funding has been determined by the "state of the art" in each scientific discipline and the available supply of practitioners of those disciplines.

In the last analysis, therefore, our expenditures on science reflect the number of scientists in being and the number in training.

Despite the great publicity given to science and its accomplishments, the proportion of high school and college graduates who choose careers in science has not been rising significantly. But since the total number of students continues to rise as a consequence of our increase in population and the fortunate circumstances which make it possible for increased numbers of high school graduates to go to college and of college graduates to undertake graduate education, the total number of potential scientists continues to rise.

The scientific frontiers are by no means closed. Each scientific venture raises more problems than it answers and this trend will continue for many years to come. Those who share the belief that science and its derivative technology will continue to expand our wealth, increase our health, and assure our safety, see no objection to an ever-increasing scientific force until such time as the scientific enterprise grows to such proportion that it becomes too expensive for our Nation to maintain. I cannot state with any conviction what the level of effort—relative to the gross national product—may be. But I am convinced that it is an effort vastly larger than that which we currently manage. Accordingly, I believe that projections for the support of science over the next 10 years or so should be based on the numbers of graduate students which may be anticipated, the size of the scientific force which will be so created, and the costs of their investigations. The estimate that this program can be maintained if the funds provided increase at a rate of approximately 15 percent per year has been validated by a series of approaches. The 15-percent figure is not a magic number but rests on rather sound grounds including the number of academic scientists currently active, the rate of attrition from this force, the number of new graduate students to be expected from among those currently in college, the increased sophistication of scientific research, and a conservative estimate of inflationary trends.

Meanwhile, our colleges and graduate schools simply must expand their activity so as to assure future college graduates of the kind of education to which they aspire. This will require investment in physical plant, and continuing expansion of the university faculties by retention of substantial numbers of their own products. But this pattern does not differ dramatically from which we have witnessed in the last 10 years. Only the scale of the enterprise is to be expanded and that in proportion to our growing national population and national wealth.

Finally, a few concluding remarks.

1. There is a subtle value to the role of the Foundation within the total Federal support of science which is difficult to document. But it is nevertheless true that it is the Foundation which gives "tone" and dignity to this enterprise. Science, supported through the Foundation, is clearly one of the most highly civilized of human activities and the understanding of man and the universe in which he finds himself is among the noblest of human aspirations. The manner and attitudes of the Foundation in the support of science increasingly serve as a model for other agencies, both public and private.

2. Quite frequently, the programs of the Foundation have been justified as "science for science's sake." And whereas this attitude may be relatively widespread among scientists working at the bench, those of us who serve on the Board and on the Foundation staff are ever mindful of the social purposes of science. In viewing applications for research support and in constructing the annual budget, there is full awareness of those aspects of chemistry which will contribute ultimately to the growth of our national chemistry industry, of those aspects of biology which will contribute to improvement in human health, in agriculture, and in the quality of life, of those aspects of physics which will one day make possible improved communications, transportation, and utilization of power. Science, supported by the Foundation, is not simply an exercise in the construction of a gigantic intellectual edifice, it is preliminary to continual improvement of the human condition.

Sincerely yours,

PHILIP HANDLER,
Vice Chairman, National Science Board.

APPENDIX 4

CURRICULUM STUDY GROUPS*

A wide variety of educational projects including curriculum studies are supported by the National Science Foundation in its course content improvement programs. According to an NSF status report on the subject prepared in March 1965, almost no two of these are alike. They include, for example, NSF-sponsored conferences on course content, small-scale student experimental projects in the use of materials, NSF support of college-level commissions on various scientific subjects, and instructional equipment development.

In addition, and most prominent of all, are the so-called materials development projects—like the biological sciences curriculum study underway at the University of Colorado—which are designed to develop, try out and eventually make available a battery of instructional materials for classroom use. These include textbooks, student manuals and teachers' guides similar to those displayed to the Committee. Subjects covered at various institutions in 18 States include, besides biology, the following: physics, mathematics, social sciences, engineering, chemistry, earth sciences, elementary, and junior high school science.

The major projects of this nature supported by NSF are listed below in two groups, including those handled by (A) the Division of Pre-College Education in Science, and (B) the Division of Undergraduate Education in Science:

COURSE CONTENT IMPROVEMENT PROGRAM

TABLE A.—*Division of pre-college education in science*

Institution and project title	Director	Address of director
K-12 MATHEMATICS AND HIGH SCHOOL SCIENCE		
Stanford University, Math in Elementary Schools.	Patrick Suppes	Institute for Mathematical Studies, Stanford University, Stanford, Calif.
University of California, Chemical Education Materials Study.	George C. Pimentel	Department of Chemistry, University of California, Berkeley, Calif.
Commission on Engineering Education, Engineering Concepts Curriculum Project.	E. E. David, Jr	Bell Telephone Laboratories, Murray Hill, N.J.
Educational Services Inc., Cambridge Conference on School Mathematics.	William T. Martin	Department of Mathematics, Massachusetts Institute of Technology, Cambridge, Mass.
University of Illinois, University of Illinois Committee on School Mathematics.	Max Beberman	University of Illinois Committee on School Mathematics, University of Illinois, Urbana, Ill.
Webster College, Madison Project	Robert B. Davis	Department of Mathematics, Syracuse University, Syracuse, N.Y.
Wesleyan University, Coordinate Geometry.	Robert Rosenbaum	Dean of the Sciences, Wesleyan University, Middletown, Conn.
Educational Services Inc., Elementary Films.	David A. Page	Educational Services Inc., 164 Main St., Watertown, Mass.

*Information provided by the National Science Foundation.

Institution and project title	Director	Address of director
Stanford University, School Mathematics Study Group.	E. G. Begle	School Mathematics Study Group, Stanford University, Stanford, Calif.
Earlham College, Chemical Bond Approach.	Laurence E. Strong	Department of Chemistry, Earlham College, Richmond, Ind.
Educational Services Inc., Physical Sciences Study Committee.	Jerrold Zacharias	Educational Services Inc., 164 Main St., Watertown, Mass.
ELEMENTARY AND JUNIOR HIGH SCHOOL SCIENCE		
American Association for the Advancement of Science, Commission on Science Education.	John R. Mayor	American Association for the Advancement of Science, 1515 Massachusetts Ave., NW., Washington, D.C.
Educational Services Inc., Elementary Science Study.	Charles Walcott	Elementary Science Study, Educational Services Inc., 108 Water St., Watertown, Mass.
University of Minnesota, Math and Science Teaching Project.	James Werntz	Institute of Technology, University of Minnesota, Minneapolis, Minn.
Princeton University, Secondary School Science Project.	Frederick Ferris	Department of Geology, Princeton University, Princeton, N.J.
University of California, Science Curriculum Improvement Project.	Robert Karplus	Department of Physics, University of California, Berkeley, Calif.
University of Illinois, School Science Curruculum Project.	Richard Salinger	School Science Curriculum Project, 805 West Pennsylvania, Urbana, Ill.
Educational Services Inc., Physical Science for Junior High School.	Uri Haber-Schaim	Educational Services Inc., 164 Main Street, Watertown, Mass.
University of Illinois, Elementary School Science Project.	J. Myron Atkin, Stanley P. Wyatt.	Elementary School Science Project, University of Illinois, Urbana, Ill.
SOCIAL, BIOLOGICAL, AND EARTH SCIENCES		
Educational Services Inc., Social Science Project.	Elting Morison	Department of History, Massachusetts Institute of Technology, Cambridge, Mass.
American Geological Institute, Earth Science Curriculum Project.	Robert Heller	Earth Science Curriculum Project, Post Office Box 1559, Boulder, Colo.
American Meteorological Society, Meteorology Films.	Kenneth Spengler	Executive Secretary, American meteorological Society, 45 Beacon Street, Boston, Mass.
Association of American Geographers, High School Geography Project.	Nicholas Helburn	Department of Earth Sciences, Montana State College, Bozeman, Mont.
American Sociological Association, Sociological Resources in Secondary Schools.	Neal Gross	Graduate School of Education, Harvard University, Cambridge, Mass.
University of Colorado, Biological Sciences Curriculum Study.	Arnold Grobman	Biological Sciences Curriculum Study, University of Colorado, Boulder, Colo.

TABLE B.—*Division of undergraduate education in science*

Institution and project title	Director	Address of director
SCIENCE EDUCATION COMMISSIONS		
American Association for the Advancement of Science, Commission on Science Education.	Paul B. Sears	Department of Botany, Yale University, New Haven, Conn.
National Academy of Sciences, Commission on Educational Policy in Agriculture.	A. E. Darlow	Dean of Agriculture, Oklahoma State University, Stillwater, Okla.
George Washington University, Commission on Undergraduate Education in the Biological Sciences.	Thomas S. Hall	Department of Zoology, Washington University, St. Louis, Mo.
University of Pennsylvania, Advisory Council on College Chemistry.	Charles C. Price	Department of Chemistry, University of Pennsylvania, Philadelphia, Pa.
Commission on Engineering, Education.	William Everitt	Dean, College of Engineering, University of Illinois, Urbana, Ill.
Association of American Geographers, Commission on College Geography.	Arthur H. Robinson	Department of Geography, University of Wisconsin, Madison, Wis.
American Geological Institute, Council on Education in the Geological Sciences.	Oliver T. Hayward	Department of Geology, Baylor University, Waco, Tex.
Mathematical Association of America, Committee on the Undergraduate Program in Mathematics	W. L. Duren, Jr.	221A Thornton Hall, University of Virginia, Charlottesville, Va.
University of Michigan, Commission on College Physics.	Matthew Sands	Stanford Linear Accelerator Center, Stanford, Calif.
MATHEMATICS		
Mathematical Association of America, Films and Other Teaching Materials for College Mathematics.	Carl B. Allendoerfer	Department of Mathematics, University of Washington, Seattle, Wash.
PHYSICS		
University of Washington, Materials for Undergraduate Curriculums in Physics.	Ernest Henley	Department of Physics, University of Washington, Seattle, Wash.
ENGINEERING		
Educational Services, Inc., Motion Pictures to Improve Instruction in Fluid Dynamics.	Arthur Bryson	Educational Services, Inc., 108 Water St., Watertown, Mass.

The NSF status report of March 1965 includes a description of publication procedure, as follows:

It is desirable that the end products—textbooks, guides, films, etc.—be made available for purchase by schools for regular usage. The Foundation authorizes the grantee to enter into a contract with a publishing firm for the publication and sale of the materials. In the case of films, contracts for film rental as well as sales are permitted. The grantee is required to solicit proposals widely from the publishing industry. Each proposal is studied by the grantee and evaluated against criteria approved by the Foundation. The criteria include consideration of design, binding, and printing of the materials; proposed sales program, selling price, return of royalties; and other financial considerations. The grantee subsequently chooses one. The Foundation approves when it is satisfied that the competition has been fair and the choice of publisher made on satisfactory grounds. The grantee and the publisher then negotiate a contract. The Foundation requires that, as a minimum, the contract provides a fair return in royalties to the grantee, that the publisher may not effect a revision without prior approval, that foreign rights are controlled and that there is an adequate Government-use clause. No fixed royalty rate is required. Control of the copyright remains with the grantee.

The status report also includes a tabulation of published instructional materials, mainly textbooks, developed with NSF support. These include the 12 biology curriculum books, pamphlets, and teachers' guides displayed to the committee by Dr. Arnold B. Grobman, director of the biological sciences curriculum study located at Boulder, Colo. Other instructional materials have been developed with NSF

support on the subjects of chemistry, physics, mathematics, and elementary science. The list follows:

PUBLISHED INSTRUCTIONAL MATERIALS DEVELOPED WITH FINANCIAL SUPPORT OF THE NATIONAL SCIENCE FOUNDATION

This list is limited largely to definitive versions of printed materials (textbooks, laboratory guides, teachers' guides, supplementay readings) now available to any who wish to obtain them. Preliminary experimental versions, special reports, films, other audiovisual aids, and equipment are not listed here.

I. Biological sciences curriculum study (BSCS)

1. Blue version: "Biological Sciences: Molecules to Man," Houghton Mifflin Co., 2 Park Street, Boston, Mass., 02107. (Molecular and evolutionary approach.) Includes text, students' manual, teachers' guide.
2. Green version: "High School Biology, BSCS Green Version," Rand McNally Co., Post Office Box 7600, Chicago, Ill., 60680. (Ecological and evolutionary approach.) Includes text, students' manual, teachers' guide.
3. Yellow version: Biological Science: An Inquiry Into Life," Harcourt Brace & World Co., 757 Third Avenue, New York, N.Y., 10017. (General and cellular approach.) Includes student laboratory guide, teachers' manual for student laboratory guide, teachers' guide.
4. "BSCS Version Quarterly Tests" (version publishers).
5. "BSCS Comprehensive Final Exam," Psychological Corp., 304 East 45th Street, New York, N.Y., 10017.
6. Laboratory Blocks, D. C. Heath & Co., 285 Columbus Ave., Boston, Mass., 02116:
   "Plant Growth and Development."
   "Animal Growth and Development."
   "Microbes: Their Growth, Nutrition and Interaction."
   "Interdependence of Structure and Function."
   "Genetic Continuity."
   "Life in the Soil."
   "Metabolism."
   "Physiological Adapability in Animals."
   "Field Ecology."
7. "Innovations in Equipment and Techniques for the Biology Teaching Laboratory," D. C. Heath & Co.
8. "Biology Teachers' Handbook," John Wiley & Sons, Inc., 605 Third Avenue, New York, N.Y., 10016.
9. "Research Problems in Biology: Investigations for Students," series 1 and series 2, Doubleday & Co., Inc., 501 Franklin Avenue, Garden City, N.Y., 11530.
10. BSCS pamphlet series, D. C. Heath & Co. (16 titles; more coming).
11. BSCS bulletin series, BSCS, University of Colorado, Boulder, Colo., 80304:
    "Biological Education in American Secondary Schools, 1890–1960" (Hurd).
    "Teaching High School Biology: A Guide to Working with Potential Biologists" (Brandwein, Metzner, Morholt, Roe, Rosen).
    "BSCS Biology: Implementation in the Schools" (Grobman, Hurd, Klinge, Lawler, Palmer).
12. BSCS special publication series, BSCS:
    "BSCS Biology Guidelines for Preparation of In-Service Teachers," No. 1 (Klinckmann).
    "Patterns for the Preparation of BSCS Biology Teachers," No. 2 (Cox).
    "BSCS Materials for Preparation of In-Service Teachers of Biology," No. 3 (Andrews).

II. Chemical bond approach project (CBA)

"Chemical Systems," McGraw-Hill Book Co., Inc., 330 West 42d Street, New York, N.Y., 10036; also teacher's guide.

"Investigating Chemical Systems" (McGraw-Hill); also teacher's guide.

"Supplementary Readings for Chemical Bond Approach," reprinted from "Scientific American," W. H. Freeman & Co., 660 Market Street, San Francisco, Calif., 94104.

"Supplementary Readings for Chemical Bond Approach," reprinted from "Journal of Chemical Education," Chemical Education Publishing Co., 20th and Northampton Streets, Easton, Pa., 18042.

III. Chemical education material (Chems)

1. Available from W. H. Freeman & Co., CHEM Study, 660 Market Street. San Francisco, Calif., 94104.
   "Chemistry: An Experimental Science."
   Laboratory Manual: "Chemistry: An Experimental Science."
   "Teacher's Guide for Chemistry: An Experimental Science," 2 volumes.
   "CHEM Study Achievement Examinations."
   Programed Instruction Pamphlets: "Use of Exponential Notation, Use of the Slide Rule."

IV. Physical science study committee (PSSC)

"Physics," D. C. Heath & Co., 285 Columbus Avenue, Boston, Mass., 02116.

"P.S.S.C. Physics. Teacher's Resource Book," parts 1, 2, 3, 4, D. C. Heath & Co., 285 Columbus Avenue, Boston, Mass., 02116.

"Physics Laboratory Guide," D. C. Heath & Co.

"Tests of the Physical Science Study Committee," Educational Testing Service, Princeton, N.J., 08540.

"Teacher's Guide to the PSSC Films," Modern Learning Aids, 3 East 54th Street, New York, N.Y., 10022.

Science study series, paperback books (38 titles), Doubleday & Co., Inc., 501 Franklin Avenue, Garden City, N.Y., 11530.

V. School mathematics study group (SMSG)

1. Published by Yale University Press, School Mathematics Study Group, 92A Yale Station, New Haven, Conn., 06520. Each item includes a student text and a teacher's commentary:
   "Mathematics for the Elementary School," spearate for grades 4, 5, 6.
   "Mathematics for Junior High School," volume 1 and volume 2.
   "Introduction to Secondary School Mathematics," volume 1 and volume 2.
   "Introduction to Algebra."
   "First Course in Algebra."
   "Geometry."
   "Geometry with Coordinates."
   "Intermediate Mathematics."
   "Elementary Functions."
   "Introduction to Matrix Algebra."
2. Available from A. C. Vroman, Inc., 367 South Pasadena Avenue, Pasadena, Calif., 91105.
   a. Studies in mathematics (for teachers):
      "Euclidean Geometry Based on Ruler and Protractor Axioms."
      "Structure of Elementary Algebra."
      "Geometry."
      "Concepts of Informal Geometry."
      "Number Systems."
      "Intuitive Geometry."
      "Concepts of Algebra."
   b. "Mathematics for the Elementary School," separate for grades K, 1, 2, 3.
   c. Mathematics through science:
      "Measurement and Graphing."
      "Graphing, Equations and Linear Functions."
      "An Experimental Approach to Functions."
   d. "Programed First Course in Algebra" (3 versions).
   e. "Analytic Geometry."
   f. "Very Short Course in Mathematics for Parents."
   g. Conference reports:
      "Conference on Elementary School Mathematics."
      "Orientation Conference for SMSG Experimental Centers."
      "Orientation Conference for SMSG Elementary School Experimental Centers."
      "Orientation Conference for Geometry With Coordinates."
      "Conference on Future Responsibilities for School Mathematics."
   h. Junior high school mathematics units:
      "Number Systems."
      "Geometry" (separate text and commentary).
      "Applications" (separate text and commentary).
   i. "Study Guides in Mathematics" (for teachers—algebra, geometry, number theory, probability, and statistics).

j. "Study Guides in Calculus."

k. Supplementary units:

"Junior High School Supplementary Unit" (separate text and commentary).

"Essays on Number Theory," I and II.

"Development of the Real Number System."

l. Supplementary and enrichment series.

"Functions."

"Circular Functions."

"Functions, Circular Functions" (teacher's commentary).

"The Complex Number System" (separate text and commentary).

"The System of Vectors" (separate text and commentary).

"Non-Metric Geometry" (separate text and commentary).

"Plane Coordinate Geometry" (separate text and commentary).

"Inequalities" (separate text and commentary).

m. Spanish translations:

"Matemáticas Para el Primer Ciclo Secundario," volume 1.

"Matemáticas Para el Primer Ciclo Secundario," volume 2.

"Matemática Para la Escuela Scundaria, Primer Curso de Algebra."

"Matemática Para la Escuela Secundaria, Geometria."

3. Available from New Mathematical Library, L. W. Singer Co., Inc., 249–259 West Erie Boulevard, Syracuse, N.Y., 13202:

"Numbers—Rational and Irrational" (Niven).

"What is Calculus About?" (Sawyer).

"An Introduction to Inequalities" (Beckenbach, Bellman).

"Geometric Inequalities" (Kazarinoff).

"The Lore of Large Numbers" (Davis).

"The Contest Problem Book."

"Uses of Infinity" (Zippin).

"Geometric Transformations" (Yaglom, Shields).

"Continued Fractions" (Olds).

"Graphs and Their Uses" (Ore).

'Hungarian Problem Book," volume 1 and volume 2 (Rapaport).

'Episodes From the Early History of Mathematics" (Aaboe).

VI. Some other publications of interest

1. Survey of recent East European literature on school and college mathematics: List of books, pamphlets, etc. (over 50 titles) available in English translation may be requested of Dr. Alfred L. Putnam (project director), department of mathematics, University of Chicago, Chicago, Ill., 60637.

2. Topics in mathematics, D. C. Heath & Co., 285 Columbus Avenue, Boston, Mass., 02116:

"Algorithms and Automatic Computing Machines" (Trakhtenbrot).

"Areas and Logarithms" (Markushevich).

"Computation of Areas of Oriented Figures" (Lopshits).

"Configuration Theorems" (Argunov, Skornyakov).

"Equivalent and Equidecomposable Figures" (Boltyanskii).

"The Fibonacci Numbers" (Vorobyov).

"How To Construct Graphs" (Shilov) with "Simplest Maxima and Minima Problems" (Natanson).

"Hyperbolic Functions" (Shervatov).

"Induction in Geometry" (Golovina, Yaglom).

"Introduction to the Theory of Games" (Venttsel').

"The Method of Mathematical Induction" (Sominskii).

"Mistakes in Geometric Proofs" (Dubnov).

"Proof in Geometry" (Fetisov).

"Summation of Infinitely Small Quantities" (Natanson).

"What Is Linear Programing?" (Barsov).

3. Published by the School Mathematics Study Group (as vol. IV of "Studies in Mathematics") and available from A. C. Vroman, Inc., 367 South Pasadena Avenue, Pasadena, Calif., 91105.

"Geometry" (Kutuzov).

4. Published by D. C. Heath & Co.

"Convex Figures and Polyhedra" (Lyusternik).

"Eight Lectures on Mathematical Analysis" (Khinchin).

"Geometric Construction in the Plane" (Argunov, Balk).

"Geometry of the Straightedge and Geometry of the Compass" (Zetel').

"Infinite Series" (Markushevich).

"Isoperimetry: Maximal and Minimal Properties of Geometric Figures" (Kryzhanovskii).
"Multicolor Problems" (Dynkin, Uspenskii).
"Probability and Information" (Yaglom and Yaglom).
"Problems in the Theory of Numbers" (Dynkin, Uspenskii).
"Random Walks" (Dynkin, Uspenskii).

5. Published by Holden-Day, Inc., 728 Montgomery Street, San Francisco, Calif., 94111:
"Challenging Mathematical Problems with Elementary Solutions," vol. I: "Combinatorial Analysis" (Yaglom and Yaglom).
"Challenging Mathematical Problems with Elementary Solutions," vol. II: "Various Branches of Mathematics" (Yaglom and Yaglom).

6. Published by Pergamon Press, Inc., New York-London, available from The Macmillan Co., 60 Fifth Avenue, New York, N.Y., 10011:
"Envelopes" (Boltyanskii).
"Shortest Paths" (Lyusternik).
"Successive Approximation" (Vilenkin).
"Systems of Linear Equations" (Margulis).

7. American Geological Institute: "Geology and Earth Sciences Sourcebook for Elementary and Secondary Schools," Holt, Rinehart & Winston, Inc., 383 Madison Avenue, New York, N.Y., 10017.

8. Committee on the Undergraduate Program in Mathematics, Mathematical Association of America, Post Office Box 1024, Berkeley, Calif., 94701:
"Course Guides for the Training of Teachers of Junior High and High School Mathematics."
"Recommendations for the Training of Teachers of Mathematics, A Summary."

9. "Laboratory and Field Studies in Biology, a Source Book for Secondary School," Teacher and student eds., Holt, Rinehart & Winston.

10. "Goals for School Mathematics, the Report of the Cambridge Conference on School Mathematics," Houghton Mifflin Co., 2 Park Street, Boston, Mass., 02107.

11. "The Teaching of Anthropology" (Mandelbaum, Lasker, Albert), University of California Press, Berkeley, Calif., 94720.

12. "Resources for the Teaching of Anthropology" (Mandelbaum, Lasker, Albert), University of California Press.

13. "Laboratory Experiments in General Physiology," American Physiological Society, 9650 Wisconsin Avenue, Washington, D.C., 20014.

14. "Laboratory Experiments in Elementary Human Physiology," American Physiological Society.

15. "Twenty-Six Afternoons of Biology" (Wald, Albersheim, Dowling, Hopkins, Lacks), Addison-Wesley Publishing Co., Inc., Reading, Mass., 01867 (college level).

16. "Novel Experiments in Physics," Committee on Apparatus for Educational Institutions of the American Association of Physics Teachers, American Institute of Physics, 335 East 45th Street, New York, N.Y., 10017.

17. "Berkeley Physics Course," McGraw-Hill Book Co., Inc., 330 West 42d Street, New York, N.Y., 10036:
"Berkeley Physics Course," text, vol. 1.
"Laboratory Physics, Part A: Berkeley Physics Laboratory."

18. Semiconductor Electronics Education Committee Books, Johy Wiley & Sons, Inc., 605 Third Avenue, New York, N.Y., 10016:
"Introduction to Semiconductor Physics" (Adler, Smith, Longini), vol. 1.
"Physical Electronics and Circuit Models of Transistors" (Gray, DeWitt, Boothroyd, Gibbons), vol. 2.
"Elementary Circuit Properties of Transistors" (Searle, Boothroyd, Angelo, Pederson), vol. 3.

19. Elementary Science Study (Educational Services Inc.), Houghton Mifflin Co., 2 Park Street, Boston, Mass., 02107. Inspection packages available February 1965 on:
"Growing Seeds," grades 1–3.
"Behavior of Meal Worms," grades 5–8.
"Kitchen Physics—A Look at Some Properties of Physics," grades 5–8.
"Gases and Airs," grades 5–8.
"Small Things—An Introduction to the Microscopic World," grades 4–6.

APPENDIX 5

SURVEY OF MEMBERS OF THE NATIONAL ACADEMY OF SCIENCES

LIBRARY OF CONGRESS,
LEGISLATIVE REFERENCE SERVICE,
Washington, D.C., August 2, 1965.

To: P. B. Yeager, House Science and Astronautics Committee, Subcommittee on Science, Research and Development.
From: W. H. Donnelly, Science Policy Research Division.
Subject: Information about NAS members.

At our meeting on July 23 you requested information about the colleges where members of the National Academy of Sciences (those elected since 1960) did their undergraduate study.

There is attached a list of the members of the Academy showing the baccalaureate institution for each—except where foreign colleges were involved—and also the current enrollment of these colleges and the type of degree given. This latter information on enrollment and education comes from the Education Directory, 1963–64 on Higher Education published by the Office of Education of DHEW in 1964.

In summary form, one finds the following distribution of these colleges, in terms of their present student body:

Enrollment	NAS members	Percent
Up to 2,000 students	24	12.0
2,000 to 5,000 students	24	12.0
5,000 to 10,000 students	21	10.6
10,000 and over students	88	44.4
Educated abroad	41	20.7
Total	198	

The second added column indicates the highest degree awarded by each institution: (1) is less than a 4-year degree; (2) is a 4-year degree; (3) is 1 year's graduate study; (4) is a Ph. D. degree. The letters indicate type of institution: (b) is liberal arts and general; (c) liberal arts and general and terminal-occupational; (e) and (f) are liberal arts with business or teacher education; (g) is professional only; (h) is professional and teacher preparatory; (j) is liberal arts with one to two professional schools; (k) is liberal arts with more than two professional schools.

Name	Year elected	Baccalaureate institution	Enrollment	Classification
Robert Arnold Alberty	1965	University of Nebraska	10,401	4(k)
Lawrence Hugh Aller	1962	University of California	91,045	4(k)
Herbert Lawrence Anderson	1960	Columbia College	849	2(b)
Thomas Foxen Anderson	1964	California Institute of Technology	1,339	4(g)
Christian Boehmer Anfinsen	1963	Swarthmore	977	3(b)
James Richard Arnold	1964	Princeton	4,196	4(k)
William Archibald Arnold	1962	California Institute of Technology	1,339	4(g)
Daniel Israel Arnon	1961	University of California	91,045	4(k)
Allen Varley Astin	1960	University of Utah	13,448	4(k)
James Gilbert Baker	1965	University of Louisville	6,652	4(k)
William Oliver Baker	1961	Washington College (Medical)	486	2(e)
Seymour Benzer	1961	Brooklyn College	20,314	3(f)
Lipman Bers	1964	Latvia	Foreign	
R. H. Bing	1965	Southwestern Texas State Teachers	3,467	3(f)
David Harold Blackwell	1965	University of Illinois	33,956	4(k)
Nicolaas Bloembergen	1960	Netherlands	Foreign	
Alfred Theodore Blomquist	1960	University of Illinois	33,956	4(k)
Virgil Carl Boekelheide	1962	University of Minnesota	45,849	14(k)
Henry George Booker	1960	England	Foreign	
Raoul Bott	1964	Canada	Foreign	
Harry Alfred Borthwick	1961	Stanford	9,934	4(k)
Robert John Braidwood	1964	University of Michigan	30,152	4(k)
Armin Charles Braun	1960	University of Wisconsin	35,251	4(k)
Robert William Briggs	1962	Boston University	19,589	4(k)
Harvey Brooks	1962	Yale	8,364	4(k)
John Machlin Buchanan	1962	DePauw University	2,331	3(j)
George H. Buchi	1965	Switzerland	Foreign	
Theodore Holmes Bullock	1963	University of California, Berkeley	91,045	4(k)
Robert Harza Burris	1961	South Dakota State	3,455	4(k)
Joseph Wyan Chamberlain	1965	University of Missouri	23,204	4(k)
Owen Chamberlain	1960	Dartmouth	3,404	4(k)
Erwin Chargaff	1965	Austria	Foreign	
Jule Gregory Charney	1964	University of California, Los Angeles	91,045	4(k)
Chiing-Shen Chern	1961	China	Foreign	
Geoffrey Foucar Chew	1962	George Washington University	14,031	4(k)
Robert Frederick Christy	1965	Canada	Foreign	
Preston Ercelle Cloud, Jr	1961	George Washington University	14,031	4(k)
Julius Hiram Comroe, Jr	1961	University of Pennsylvania	18,347	4(k)
Robert Elwell Connick	1963	University of California	91,045	4(k)
Albert Hewett Coons	1962	Williams	1,228	3(b)
Donald James Cram	1961	Rollins	2,013	3(e)
James Franklin Crow	1961	Friends University	628	2(e)
David Yarrow Curtin	1964	Swarthmore	977	3(b)
Lawrence Stamper Darken	1961	Hamilton	831	2(b)
Philip Jackson Darlington, Jr	1964	Harvard	12,413	4(k)
Norman Ralph Davidson	1960	University of Chicago	8,233	4(k)
Vincent Gaston Dethier	1965	Harvard	12,413	4(k)
Carl Djerassi	1961	Kenyon	601	2(j)
William von Eggers Doering	1961	Harvard	12,413	4(k)
Michael Doudoroff	1962	Stanford University	9,934	4(k)
Harry George Drickamer	1965	University of Michigan	30,152	4(k)
Renato Dulbecco	1961	Italy	Foreign	
Freeman John Dyson	1964	England	Foreign	
Harry Eagle	1963	Johns Hopkins University	8,240	4(k)
Harold Eugene Edgerton	1964	University of Nebraska	10,404	4(k)
Fred Russell Eggan	1963	University of Chicago	8,233	4(k)
Alfred Edwards Emerson	1962	Cornell University	12,687	4(k)
William Kaye Estes	1963	University of Minnesota	45,849	4(k)
William Martin Fairbank	1963	Whitman College	888	2(e)
William Feller	1960	Yugoslavia	Foreign	
Louis Barkhouse Flexner	1964	University of Chicago	8,233	4(k)
Scott E. Forbush	1962	Case School of Applied Science	2,482	4(g)
Charles Stacy French	1963	Harvard	12,413	4(k)
Herbert Friedman	1960	Brooklyn College	20,314	3(f)
Herbert Friedmann	1962	City College	30,307	3(k)
Robert Galambos	1960	Oberlin	2,430	3(j)
Wendell Richard Garner	1965	Franklin & Marshall	1,912	3(e)
Robert Minard Garrels	1962	University of Michigan	30,152	4(k)
Murray Gell-Mann	1960	Yale	8,364	4(k)
Alfred Gilman	1964	do	8,364	4(k)
Donald Arthur Glaser	1962	Case Institute	2,482	4(g)
Marvin Leonard Goldberger	1963	Carnegie Institute	4,984	4(h)
Louis Sanford Goodman	1965	Reed College	884	3(e)
Walter Gordy	1964	Mississippi College	1,748	3(e)
Sam Granick	1965	University of Michigan	30,152	4(K)
David Ezra Green	1962	New York University	33,232	4(K)
Joseph Harold Greenberg	1965	Columbia College	849	2(b)
Donald Redfield Griffin	1960	Harvard	12,413	4(K)
Irwin Clyde Gunsalus	1965	Cornell University	12,687	4(K)
Herbert Sander Gutowsky	1960	Indiana University	31,581	4(K)
George Simms Hammond	1963	Bates College	894	2(b)
Alfred Irving Hallowell	1961	University of Pennsylvania	18,347	4(K)
Philip Handler	1964	City College of New York	30,307	3(K)
Bernhard Haurwitz	1960	Germany	Foreign	

Name	Year elected	Baccalaureate institution	Enroll-ment	Classi-fication
Leland John Haworth	1965	Indiana University	31,581	4(K)
Hollis Dow Hedberg	1960	University of Kansas	11,431	4(K)
George Howard Herbig	1964	University of Calif., Los Angeles	91,045	4(K)
Paul Herget	1962	University of Cincinnati	20,261	4(K)
Karl Ferdinand Herzfeld	1960	Austria	Foreign	
Terrell Leslie Hill	1965	University of California	91,045	4(K)
Klaus Heinrich Hofmann	1963	Germany	Foreign	
Bernard Leonard Horecker	1961	University of Chicago	8,233	4(K)
Rollin Douglas Hotchkiss	1961	Yale	8,364	4(K)
Hoyt Clarke Hottel	1963	Indiana University	31,581	4(K)
Carl Iver Hovland	1960	Northwestern	16,636	4(K)
Robert Joseph Huebner	1960	St. Louis University	9,045	4(K)
Clyde Allen Hutchison, Jr	1963	Cedarville College	Small	
Libbie Henrietta Hyman	1961	University of Chicago	8,233	4(K)
Mark Gordon Inghram	1961	Olivet College	609	2(e)
Dwight Joyce Ingle	1963	University of Idaho	5,254	4(k)
Leon Orris Jacobson	1965	North Dakota State College	398	1(·)
Harold Lloyd James	1962	State College of Washington	8,310	4(k)
Fritz John	1964	Germany	Foreign	
Clarence Leonard Johnson	1965	University of Michigan	30,152	4(k)
Harold Sledge Johnston	1965	Emory University	4,646	4(k)
Mark Kac	1965	Poland	Foreign	
Martin David Kamen	1962	University of Chicago	8,233	4(k)
Walter Joseph Kauzmann	1964	Cornell University	12,687	4(k)
Eugene Patrick Kennedy	1964	DePaul University	9,147	3(k)
Seymour Solomon Kety	1962	University of Pennsylvania	18,347	4(k)
Augustus Braun Kinzel	1960	Columbia University	24,000	4(k)
Leon Knopoff	1963	California Institute of Technology	1,339	4(g)
Paul Jackson Kramer	1962	Miami University (Ohio)	11,700	3(k)
Otto Krayer	1964	Germany	Foreign	
Stephen William Kuffler	1964	Hungary	Foreign	
Leon Max Lederman	1965	City College of New York	30,397	3(k)
Tsung-Dao Lee	1964	China	Foreign	
Hans Lewy	1964	Germany	Foreign	
Chia-Chiao Lin	1962	China	Foreign	
William Nunn Lipscomb, Jr	1961	University of Kentucky	11,242	4(k)
Franklin A. Long	1962	University of Montana	4,380	4(k)
Oliver Howe Lowry	1964	Northwestern University	16,636	4(k)
Salvador Edward Luria	1960	Italy	Foreign	
Gordon James Fraser MacDonald	1962	Harvard	12,413	4(k)
George Whitelaw Mackey	1962	Rice Institute	2,122	4(j)
Joseph Hoover Mackin	1963	New York University	33,232	4(k)
Herman Francis Mark	1961	Austria	Foreign	
Bernd T. Matthias	1965	Germany	Foreign	
Daniel Mazia	1960	University of Pennsylvania	18,347	4(k)
Maclyn McCarty	1963	Stanford University	9,934	4(k)
Harden Marsden McConnell	1965	George Washington University	14,031	4(k)
William David McElroy	1963	Stanford University	9,934	4(k)
Charles Duncan Michener	1965	University of California, Berkeley	91,045	4(k)
George Armitage Miller	1962	University of Alabama	14,447	4(k)
Clark Blanchard Millikan	1964	Yale	8,364	4(k)
John Willard Milnor	1963	Princeton	4,196	4(k)
John Alexander Moore	1963	Columbia University	24,000	4(k)
Stanford Moore	1960	Vanderbilt University	4,202	4(k)
Charles Bradfield Morrey, Jr	1962	Ohio State University	30,500	4(k)
George Peter Murdock	1964	Yale	8,364	4(k)
David Nachmansohn	1965	Russia	Foreign	
James Van Gundia Neel	1963	College of Wooster	1,415	2(e)
William Duwayne Neef	1964	University of Illinois	33,956	4(k)
Hans Neurath	1961	Austria	Foreign	
Jerzy Neyman	1963	Rumania	Foreign	
Abraham Pais	1962	Netherlands	Foreign	
George Emil Palade	1961	Rumania	Foreign	
John Richard Pappenheimer	1965	Harvard	12,413	4(k)
Bryan Patterson	1963	England	Foreign	
William Thomas Pecora	1965	Princeton	4,196	4(k)
Isadore Perlman	1963	University of California, Berkeley	91,045	4(k)
William Hayward Pickering	1962	California Institute of Technology	1,339	4(g)
Gregory Pincus	1965	Cornell University	12,687	4(k)
Emanuel Ruben Piore	1963	University of Wisconsin	35,251	4(k)
Colin Stephenson Pittendrigh	1963	England	Foreign	
Keith Roberts Porter	1964	Canada	Foreign	
Robert Vivian Pound	1961	University of Buffalo	Big	
Theodore Thomas Puck	1960	University of Chicago	8,233	4(k)
John Robert Raper	1964	University of North Carolina	8,852	4(h)
Oscar Knefler Rice	1964	University of California, Berkeley	91,045	4(k)
Lorrin Andrews Riggs	1961	Dartmouth	3,401	4(k)
Richard Brooke Roberts	1961	Princeton	4,196	4(k)
Kenneth David Roeder	1964	England	Foreign	
Irving Rouse	1962	Yale	8,364	4(k)
Allan Rex Sandage	1963	University of Illinois	33,956	4(k)
Knut Schmidt-Nielsen	1963	Norway	Foreign	
Per Fredrik Scholander	1961	do	Foreign	

Name	Year elected	Baccalaureate institution	Enrollment	Classification
Ernest Robert Sears	1964	Oregon State College	10,026	4(k)
Charles Donald Shane	1961	University of California	91,045	4(k)
James Augustine Shannon	1965	College of the Holy Cross	1,827	3(b)
Albert Charles Smith	1963	Columbia University	24,000	4(k)
Emil L. Smith	1962	do	24,000	4(k)
Donald Clayton Spencer	1961	University of Colorado	19,557	4(k)
Roger Wolcott Sperry	1960	Oberlin College	2,430	3(j)
Sol Spiegelman	1965	City College of New York	30,307	3(k)
Philip Sporn	1962	Columbia University	24,000	4(k)
William Howard Stein	1960	Harvard	12,413	4(k)
Thomas Dale Stewart	1962	George Washington University	14,031	4(k)
James Johnston Stoker	1963	Carnegie Institute	4,984	4(h)
Henry Melson Stommel	1961	Yale	8,364	4(k)
Wilson Stuart Stone	1960	University of Texas	23,747	4(k)
Gilbert Josse Stork	1960	University of Florida	13,826	4(k)
William Louis Straus, Jr	1962	Johns Hopkins University	8,240	4(k)
Leo Szilard	1961	Hungary	Foreign	
Alfred Tarski	1965	Poland	Foreign	
Richard N. Tousey	1960	Tufts College	4,586	4(k)
Charles Hard Townes	1956	Furman University	1,491	3(e)
John Wilder Tukey	1961	Brown University	4,281	4(e)
Richard Baldwin Turner	1964	Harvard	12,413	4(k)
Frederick Theodore Wall	1961	University of Minnesota	45,849	4(k)
Cheves Thomson Walling	1964	Harvard	12,413	4(k)
Shields Warren	1962	Boston University	19,589	4(k)
Sherwood Larned Washburn	1963	Harvard	12,413	4(k)
Aaron Clement Waters	1964	University of Washington	23,906	4(k)
James Dewey Watson	1962	University of Chicago	8,233	4(k)
Ernst Weber	1965	Austria	Foreign	
Waldo Rudolph Wedel	1965	University of Arizona	16,275	4(k)
Alvin Martin Weinberg	1961	University of Chicago	8,233	4(k)
Thomas Huckle Weller	1964	University of Michigan	30,152	4(k)
Gian-Carlo Wick	1963	Italy	Foreign	
Jerome Bert Wiesner	1960	University of Michigan	30,152	4(k)
Raymond Louis Wilder	1963	Brown University	4,281	4(e)
Gordon Randolph Willey	1960	University of Arizona	16,275	4(k)
Carroll Milton Williams	1960	University of Richmond	3,555	3(j)
John Harry Williams	1961	Canada	Foreign	
Olin Chaddock Wilson	1960	University of California, Berkeley	91,045	4(k)
Abel Wolman	1963	Johns Hopkins University	8,240	4(k)
Clinton Nathan Woolsey	1960	Union College	2,846	4(k)
Chen Ning Yang	1965	China	Foreign	
Antoni Zygmund	1960	Poland	Foreign	

APPENDIX 6

Staff Survey of Nonprofit Research Institutes[1]

Coincident with the National Science Foundation hearings, the committee explored the nature and extent of scientific research performed by the various nonprofit research institutes in the United States. A poll of 12 such institutes was taken, asking 2 questions:

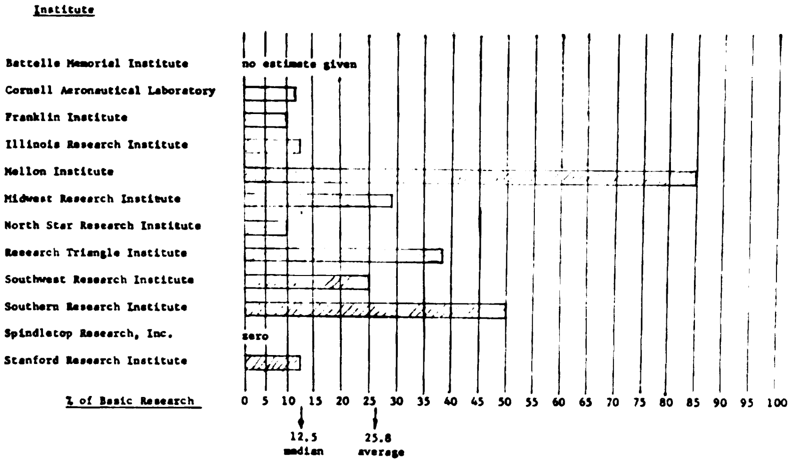
1. What percentage of your research activity do you consider to be basic research?
2. Does your institute at this time have any contract with or does it have a research grant from the National Science Foundation? If so, of what nature and amount? (If you have had such assistance in the past, the same data on it would be useful.)

The results are tabulated in three accompanying charts. Chart No. 1 shows that the proportion of basic research performed by the private institutes varies from 0 to 85 percent of their total research activity, with an average in the vicinity of 25 percent. It is apparent that the institutes operate primarily as contract laboratories in applied research.

Chart No. 1

PERCENTAGE OF BASIC RESEARCH

of the Total Research Activity of 12 Institutes



[1] Staff of the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics.

Although no uniform precise definition of "basic research" evolved from the inquiry, a generally acceptable interpretation might be that basic research is any research yielding completely new scientific knowledge of lasting value. Many institute directors noted that there is wide latitude among scientists in their concept of basic research as against applied or developmental research. Some preferred to call it fundamental or exploratory research. Battelle Institute declined as a matter of policy to offer a percentage estimate.

The highest estimate—85 percent by the Mellon Institute—is a calculated average of a total program, including independent research supported by endowment funds, reported as 100 percent basic; research supported by Government, 90 percent basic; and research supported by industry, 75 percent basic.

Chart No. 2 shows that 7 of the 12 institutes have received NSF assistance, 5 with current contracts or grants. The NSF criteria for support of nonprofit institutions have been stated by Director Leland J. Haworth, in his reply to committee questions, as follows:

> The Foundation's present policy is to emphasize support of research which also contributes to graduate and postdoctoral education in the sciences. Hence, grants will normally be made to nonprofit institutions only when they can demonstrate a close relationship to such education. However, special consideration will be given when the proposed research is judged to be of exceptional significance or where the institution has unique capabilities.

CHART NO. 2.—*National Science Foundation contracts and grants*

Institute	National Science Foundation funding	Number of projects	Years
Battelle Memorial Institute	$396,191	9	1954–65.
Cornell Aeronautical Laboratory	59,295	1	Current.
Franklin Institute	494,540	9	Current.[1]
Illinois Research Institute	None		
Mellon Institute	570,155	9	Current.[2]
Midwest Research Institute	23,570	4	1958–61.
North Star Research Institute	None		
Research Triangle Institute	52,000	1	1959.
Southwest Research Institute	None		
Southern Research Institute	None		
Spindletop Research, Inc	None		
Stanford Research Institute	162,100	3	1963–65.

[1] Franklin Institute for the past 5 years has received an average of about $225,000 annually in National Science Foundation assistance.

[2] Mellon Institute's annual rate of new National Science Foundation grants and contracts is approximately $95,000.

Chart No. 3 compares each institute's overall proportion of basic research with the degree of National Science Foundation funding. It reveals no direct relationship. For example, the two institutes reporting the largest sums of National Science Foundation con-

tracts and grants—Mellon and Franklin, each around $500,000—estimate their basic research respectively at 85 percent and 10 percent of their total workloads. And the institute reporting the second highest proportion of basic research—Southern at 50 percent—has received no National Science Foundation help at all.

CHART NO. 3.—*Relationship of National Science Foundation support to proportion of institute's basic research program*

Institute	National Science Foundation funding	Percentage of total workload considered to be basic research
Battelle Memorial Institute	$396, 191	No estimate given.
Cornell Aeronautical Laboratory	59, 295	12 percent.
Franklin Institute	494, 540	Average of 10 percent.
Illinois Research Institute	None	10 to 15 percent.
Mellon Institute	570, 155	Average of 85 percent.
Midwest Research Institute	23, 570	25 to 33 percent.
North Star Research Institute	None	10 percent.
Research Triangle Institute	52, 000	38 percent.
Southwest Research Institute	None	25 percent.
Southern Research Institute	None	50 percent.
Spindletop Research, Inc	None	Zero.
Stanford Research Institute	162, 100	10 to 15 percent.

Despite this wide variation in comparison of total programs, the survey confirmed that all of the institute support that comes from National Science Foundation is, in fact, devoted to projects that can be legitimately justified as basic research. This is shown at Franklin Institute where, as already noted, only 10 percent of an annual budget of $13 million is considered to be basic research. Nevertheless, over 90 percent of its National Science Foundation grants—that is, $460,000 out of $494,000—are assigned to the Bartol Research Foundation, which is a Franklin laboratory that is engaged solely in basic research.

The institutional applied research contracts, which comprise their principal workload, are financed wholly from sources other than National Science Foundation.

APPENDIX 7

COMMUNICATIONS TO THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND DEVELOPMENT

BETHESDA, MD., *April 27, 1965.*

Hon. E. Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development,
House of Representatives, Washington, D.C.

DEAR SIR: I have learned with interest of your subcommittee's control measures, as they are applied to the activities of the U.S. National Science Foundation. Kindly permit me some remarks:

They don't have an ax to grind with anyone in this Foundation. I would like to point out the apparent fact that appropriations and grants have been virtually abolished for private individuals, who intend to approach the Foundation for support of their proposed projects. It looks as if applications from individuals are summarily rejected, unless perhaps the applicant is among the fortunate winners of the Nobel Prize or other financially doted awards. There, additional funds from the Foundation would seem to be quite superfluous.

This situation is obviously infested with discrimination, particularly so, if one considers the origin of the Foundation's financial means: tax money, supplied by industry and citizens, but hardly anything from the often-exempted universities.

Yet, there is frequent evidence that unaffiliated individuals contribute in a much more economic way to the evolution of science (there, the "lone wolf" theory is applicable), than the organized follower of team policy in a university-managed laboratory or in a nonprofit research foundation (here, Parkinson's laws apply).

One source of supporting arguments for the individuals and their projects, for example, provides the correspondence section of the Proceedings of the IRE (now IEEE) of the last 10 years, where scientific and technical papers are printed from both groups of contributors.

It is important to add that individualistic petitioners for grants in most cases are well-qualified scientists. But they may be in circumstantial situations that just don't permit them to join an institution on the favored-son-list of the National Science Foundation in order to get financial support for the pursuance of a scientific idea, which they even might have conceived while working on a project of their profit-eager employer corporation.

An interesting sideline that may help improving this matter can be followed by redefining and by extending the so-called postdoctoral fellowship awards of the NSF to all individuals who can prove to be scientists. One should exercise great care, that this is not done by flashing diplomas, but rather by securing mentor sponsors of the individual's own choice, and who already have contributed their own share to science.

In my own career—I must mention as a supporting argument—I have met Ph. D.'s of long standing who turned out to be more ignorant than a candidate who just passed his bachelor's examinations.

I would appreciate very much to receive your comments.

Sincerely yours,

REINHOLD GERHARZ.

UNIVERSITY OF FLORIDA,
COLLEGE OF ARTS & SCIENCES,
Gainesville, May 3, 1965.

Hon. EMILIO Q. DADDARIO,
House of Representatives,
Washington, D.C.

DEAR MR. DADDARIO: It is with keen interest that many of us look forward to the conclusions of your subcommittee in its consideration of the affairs of the National Science Foundation.

Since there has been, for some time, a rather unfortunate misunderstanding of the role which research plays in universities, it would be the hope of many of us that your subcommittee might, in its conclusions, set matters aright in this context.

To put this in the most succinct possible way, the problem is that of "research versus teaching" as compared to "research and teaching."

Now it is true, of course, that a relatively small number of persons within the general framework of academic activities spend a disproportionate amount of energy and time on research to the detriment of teaching. It is, moreover, true that the young academician is a great deal more loyal to his discipline than to his university today. But in the first instance the number is much smaller than is reputed to be and in the second instance universities today are not comparable in size to what they once were. The academic village of yesterday is the academic metropolis of today. Whether this is good or bad is not very important, and what is really germane is the fact of the situation.

The fact that "teaching loads" are smaller than they were 20 years ago does not mean that "workloads" are lighter. The situation is that most professors (particularly those active in research) have many more duties and a larger share of them than they had earlier.

1. They have a larger number of students to counsel and advise.
2. There are more graduate students whose work they must direct.
3. They are more deeply and frequently concerned with preuniversity curriculums and, at the other end of the spectrum, with postdoctoral "students."
4. Because of the increase in the size of departments, they are more involved in administrative work than earlier.

It is a popular fallacy that the "blame" for this is laid to a surfeit of research funds and vigorous competition for these funds. In some small number of instances this may be so, but colleges of medicine were never more affluent researchwise and health service was never better than is now the case.

To put it mildly, students never had it better. Their teachers are better trained (and this is improving), they are more than ever devoted to their disciplines and they have never had a greater urge to do as well as possible in faculty competition to attract students to their disciplines. Now, at least in the sciences (and hopefully, when there is a National Humanities Foundation), this best of all possible educational situations is due precisely to the fact that funds are available for research for faculty and students.

There has also been a resurgence of criticism against too much teaching by graduate students. The fact of the matter is that if all professors did nothing but teach undergraduate courses then several things would happen: (*a*) there would be no university professor being prepared for the future; (*b*) half of the undergraduates, at least, would have no teachers at all; and (*c*) progress in basic knowledge would come to a disastrously screeching halt.

Now graduate students have been teaching, both here and abroad, almost from the beginning of academic time. This is the way they make a living and this is the way universities have been getting teaching. As a matter of fact, this "practice teaching" is being required for the doctorate in more and more universities. It is not courses in "education" that matter, but the actual business of being faced with a class and being faced with the results of the final grades that counts in making teachers. I could only wish that, at my age and with my experience, I had nearly so much devotion and enthusiasm for spreading the gospel of mathematics as my young colleagues have, who are also my students in graduate courses. They have the passion for doing it, and the vigor to do it with, that many full professors with more experience and more training do not have.

It is clear as the nose on your face, that if graduate students did not teach then there would be no graduate students and, shortly, no professors.

But this is not enough—what the graduate student also needs is some free time for his training as a researcher—this is a part of the job of becoming a professor—and what his professor also needs, time to direct his research and to keep his (the professor's) research going.

At least in the sciences, this is what NSF has been able to do for universities and what would not have been done without NSF.

Taking another right turn, it does not seem to be readily apparent that mathematics and mathematicians move in interstate commerce, and the latter to a smaller extent in international commerce. The State of Florida is quite obviously concerned with the training of citrus agronomists and the State of New Jersey is not. But Florida is not vitally concerned with training petroleum geologists and Texas is greatly concerned. However, every State uses professors of mathematics and it does not make much difference in what State they are trained, if they are well trained. The point here is that the Federal Government is concerned (or should be) to a greater extent than any State (or every State) in training mathematicians. Thus far, it is to the greatest extent that NSF has been so helpful. This is not to say that other Federal agencies have not helped, but within a rather limited and specialized part of mathematics—mainly what is useful to the agency concerned. Mathematics and the training of mathematicians is a Federal concern and NSF has done an excellent job. Looking at it another way, the expected 1970 student boom is unexpected in the sense that it seems now likely to be far larger than first anticipated. Clearly, the individual States cannot possibly undertake to prepare all of the needed college teachers and university teachers of mathematics, and without NSF, neither can the Federal Government.

To put the above in its most practical and immediate fashion, perhaps your subcommittee could ascertain the origin of each Ph. D. mathematician now in academic life in Connecticut.

Aside from the English language, mathematics is the most used and the most useful of all disciplines in the sciences, and this is coming to be so in the humanities. No field, from agronomy to zoology (and including economics, genetics, psychology, and so on) fails to use some part of mathematics. In the vast majority of instances, almost all of the mathematics that is learned is taught in departments of mathematics. This is where the engineering student and the business administration student both learn mathematics. Here, the department of mathematics has the largest student load and the largest faculty of any department in the college of arts and sciences (probably in the university). Yet (and I do not think this unreasonable) the legislators in the State are a great deal more concerned with agriculture and dairy farming, and these areas are far better funded. Actually, I think that the cost per student credit is less in mathematics than in any other discipline at this university. This would not seem peculiar to this State and is probably so in general in State institutions. However, we must have more and better trained mathematicians, and more and better mathematics, and it seems clear that this situation can only be brought about by Federal assistance. And if this is to get to mathematics the initial grant must be made to mathematics.

The Congress and the administration are both very wisely concerned with the immediate practical goals of scientific research. I think, and I hope that your subcommittee might agree, that the most important of these is the preparation of scientists, because, whatever we may have now in scientific and technological know-how, it will not be worth having if we are unable to continue it and to exploit it a decade hence. While making NSF the immediate university source of research funds as a means of accomplishing this end may not, at first, seem to be the best way; it seems to be a fact that over the past 15 years this is how it has happened, particularly for mathematics. And foremost among the reasons for the effectiveness of NSF is the point just made, that mathematics and mathematicians move in interstate commerce. It is the Federal Government that can best ascertain the needs and make the allotments, via NSF.

As long as this letter is, it is merely a brief account, and Dr. Milton Rose of NSF (MPE) can give you a far better account than is contained here.

Very cordially yours,

ALEXANDER DONIPHAN WALLACE.

HIGHLAND PARK, N.J., *May 7, 1965.*

Senator CLIFFORD P. CASE,
Senate Office Building,
Washington, D.C.

DEAR SENATOR CASE: The removal of some science support from the decision-making power of Federal agencies and its replacement by block institutional grants is a critical requirement for the advance and competitive position of American research as well as education.

In our graduate schools of engineering we feel, and we know that our colleagues in the science schools feel, that—

(1) Action on research ideas, and therefore the transmittal of the resultant body of knowledge to the graduate student, is delayed and, in two-thirds of the cases suppressed by the needs to translate them into formal research projects subject to the approval of agencies with the delaying, but necessary circulation through committees.

(2) Guidance of research, faculty, and graduate body is disastrously removed from the authority of the school, resulting in disjointed and exaggerated authority of individuals proficient or lucky in project funding promotion.

(3) We find ourselves distracted and occupied by constant project generating, defending, and supervising activities which are badly encroaching on our teaching and searching life.

(4) The topics selected are unrealistically removed from and unmanageably disjointed in the body of knowledge and common search germane to a live number of persons with specific gifts in teaching and research.

I respectfully urge you to investigate and, if you find our feelings substantiated, strongly pursue changes in support policy, as advocated by the Purdue speech of the new president of the academy, Dr. F. Seitz. The new, unusual, and fortuitous availability of such a man in a full-time long term should be welcomed by active listening to his advice.

As engineers we wish, however, to stress two points implied in the address that—

(1) The project system should not be abandoned, only reduced in favor of block grants. The reason for this is the need for the university to remain formally aware of frontiers of requirements related to national welfare in the broadest sense, including defense. These needs have led to the present system and should not be disregarded in spite of the described shortcomings.

(2) The grant system should extend to the humanities. We are not entitled to prejudge the relative merits of engineering, the physical sciences, and the humanities in the light of the desires and wants of the future.

Sincerely,

NORBERT J. KREIDL,
Professor of Ceramics, Rutgers University.

UNIVERSITY OF SOUTHWESTERN LOUISIANA,
Lafayette, La., May 11, 1965.

Re review of the National Science Foundation by the Subcommittee on Science, Research, and Development.

Representative EMILIO Q. DADDARIO,
U.S. House of Representatives,
Washington, D.C.

DEAR MR. DADDARIO: I am interested in an area of higher education which is being neglected by the National Science Foundation; specifically the master of science program. The graduate trainee program, in particular, is limited to schools with Ph. D. programs. Other agencies follow a similar policy and as a result master of science programs are, for all practical purposes, being put out of business. This is happening because, without funds, we cannot compete with the Ph. D. schools for graduate students.

Failure to support master of science programs is producing such results as:

1. More schools than we need are starting Ph. D. programs in order to obtain funds. This is true particularly in chemistry where there are insufficient students to staff at least 135 Ph. D.-granting institutions.

2. College teacher training programs are best done at the master of science level. If the schools are not supported the training will cease for the Ph. D.-granting institutions have neither the time nor the interest to engage in such work.

3. If a large institution of about 2,000 to 3,000 students as a minimum figure cannot offer the M.S. degree it cannot staff its faculty with Ph. D.'s. Many candidates will not accept positions in which their full time must be devoted to elementary work, such as general chemistry, unless they are offered compensatory work at an advanced (M.S.) level.

I hope that this information will be of some value to you.

If I can be of any further information let me know. However, there is no need to add to the work of your office by acknowledging this letter.

Sincerely yours,

C. A. McKenzie,
Head, Chemistry Department.

Loma Linda University,
Laboratory of Neurological Research,
Los Angeles, Calif., May 24, 1965.

Representative E. Q. Daddario,
Subcommittee on Science, Research, and Development,
House of Representatives, Washington, D.C.

Dear Representative Daddario: As a teacher and research director in one of the smaller medical institutions in our country I wish to go on record as a strong supporter of the methods employed by the National Science Foundation in the consideration, review, and awarding of grants for research in biology and medicine.

As one who has some knowledge of the manner in which Federal funds are spent through the various granting agencies, I suggest that the National Science Foundation has consistently shown a better record for its budget than many of the other Federal granting agencies. I feel this has come about because of the Foundation's reviewing system, which tends to use a greater number of individual specialists for the subject under consideration, rather than committees (which admittedly are made up of exceedingly competent scholars, but which often tend to become "clubs" frequently composed of a sampling from a restricted number of our more learned institutions).

I have always found the reviews of the National Science Foundation in my particular area of interest to be very fair, and more dependent upon scholarship and production than the reviews by many other Federal granting agencies.

Sincerely yours,

Findlay E. Russell,
Director of Laboratory.

Pittsburgh, Pa., *May 25, 1965.*

Hon. Emilio Daddario,
House Office Building,
Washington, D.C.

Dear Congressman Daddario: The Chemical and Engineering News issue of May 3, 1965, contained an article in which it was stated that your House Subcommittee on Science, Research, and Technology will shortly probe the National Science Foundation.

This was of great interest to me both as an individual translator and as president pro tem of the newly formed American Society of Scientific & Engineering Translators (ASSET).

It is a known fact that the National Science Foundation has been getting its scientific and technical translation work done in Israel, Poland, and Yugoslavia. It is my understanding that one of the reasons given for having this material translated in the above-mentioned countries is that there is not enough competent translation talent available in the United States to satisfy NSF's requirements.

I have exchanged many letters with other translators in the United States during the past year or so and most of them informed me that they had no knowledge of the fact that the National Science Foundation was engaged in translation activities. On the other hand, I have received letters from translators who have written to the NSF about doing translation work for them with the end result that they were referred to me and other translators. As far as I know, none of them ever received any translation assignments from NSF.

This may not be important in itself, but I am of the considered opinion that it would be rather difficult to dispute the statement that research and translation activities go hand in hand. If this is true, then it is equally true that the exporting of translation work to foreign countries is detrimental to the best interests of the United States and to the practicing translators who earn their livelihood in this country.

One of the purposes of ASSET is the training of competent scientific and technical translators. ASSET believes that our Nation should at all times have a ready supply of translators who can satisfy the requirements of both Government and industry. It is rather difficult to sell a person on a translation career when so much work is leaving the country to be done abroad.

I am quite certain that there are enough competent translators in the United States who would be willing and able to handle any type of translation assignment that NSF would require.

I should be deeply grateful if you could furnish me with a final report of your investigation.

Needless to say, ASSET stands ready to cooperate with your committee in any way.

Very truly yours,

A. J. ORLUK.

OBERLIN COLLEGE,
May 25, 1965.

Interoffice to: Fred Foreman.
From: William Athony Gordon.
Subject: Letter from Representative Mosher regarding NSF.

The training of new generations of scientists is an important area where NSF has been able to exert a strong and beneficial influence. I should like to see this influence extended, particularly with reference to undergraduate training. In contrast to graduate training of scientists, which seems to be well supported in a number of direct and indirect ways, undergraduate training offers many opportunities for increased support. We have been successful ourselves in gaining help from NSF, but my impression from talking to NSF personnel and from published reports is that are too many good undergraduate education programs which cannot be supported by NSF purely because of lack of funding for the undergraduate level. The undergraduate education in the Sciences Section of NSF has two programs from which our department is at present gaining strength and I should like to see this kind of support given to many more institutions than can now be offered it. The two programs that I have in mind are the undergraduate research participation program and the undergraduate instructional scientific equipment program. These programs are being of great help to us in our role of producing graduates who will go on to advanced training in science at other institutions.

AMERICAN INSTITUTE OF PHYSICS,
New York N.Y., May 28, 1965.

Hon. EMILIO Q. DADDARIO,
Longworth House Office Building,
Washington, D.C.

DEAR SIR: Your remarks after the luncheon meeting for science writers, April 27, have raised some questions that interest the American Institute of Physics. We take this opportunity to present our thought on the relations of international scientific activities to the purpose of the National Science Foundation, but we realize that our comments here do not reflect full knowledge of the discussions that have already taken place or of the conclusions reached.

The National Science Foundation is devoted to the support of "U.S. science." We believe that what is good for U.S. science is often indistinguishable from what is good for international science, as the participation of two NSF programs so eloquently demonstrates—the International Indian Ocean Expedition and the International Year of the Quiet Sun.

Many persons acknowledge the foreign origins of much of U.S. science, but we believe that the continued growth of our science needs a continued exchange of ideas between our country and others, and increased opportunities for those who work outside their own country to retain their professional standing. We strongly endorse the visiting scientist programs such as those under the

Fulbright-Hays Act and under NSF. These programs involve individuals for only a year or so.

Our correspondence with U.S. physicists on long-term appointments in developing countries shows that they may have seriously endangered their positions on the academic ladder at home. We believe both U.S. and world science would benefit from measures that encourage qualified scientists to enter foreign service and that help them to retain their professional standing. We endorse programs that link research programs at foreign universities to those in the United States.

The provision of travel grants to attend scientific conferences in nearby countries is useful. NSF does provide travel grants, but we understand that it is difficult for those on long assignments to obtain awards.

As you know, a number of highly qualified alien scientists work at National or Government laboratories, such as Brookhaven or the Bureau of Standards, or at universities. These organizations would greatly benefit if they were able to send qualified alien scientists to conferences abroad, because they have unique qualifications or unusual language facilities. However, we understand that travel grants for such purposes are restricted to U.S. citizens. We believe these restrictions should be reviewed.

We are not concerned that there my be an occasional overlapping of international responsibilities between the National Science Foundation and the National Academy of Sciences, but only that the closest cooperation between the two agencies serve nationally the broader interests of international science.

Our outlook from the Institute, which works in behalf of our several professional societies, cannot encompass all science, but we welcome further discussion on these or other topics if the need arises.

Sincerely yours,

VAN ZANDT WILLIAMS,
Director.
F. BEHN RIGGS, JR.,
Director, Information Center on International Physics Activities.

OBERLIN COLLEGE,
DEPARTMENT OF PSYCHOLOGY,
Oberlin, Ohio, May 30, 1965.

Hon. CHARLES A. MOSHER,
Representative to Congress,
Longworth Building, Washington, D.C.

DEAR CHUCK: Thank you for soliciting comments on the National Science Foundation in connection with the Daddario subcommittee study.

While much can be said regarding the accomplishments of NSF, let me dwell on just a few of its outcomes that have impressed me a great deal.

1. Through its undergraduate research participation program it has made it possible for colleges to provide much more meaningful training of undergraduate students majoring in the sciences. While science departments have always had the objective of imparting good training along research lines, very limited budgets made it impossible for most colleges to do more than make a gesture in the direction of sound training. Today, if a department can present evidence that it knows how to make maximum use of such funds, it can compete with other departments for the support needed to upgrade instruction in the sciences. As a result of this program our majors are today receiving very sophisticated research training compared to what Fritz was able to obtain with us just a few years ago.

2. Through its undergraduate instructional equipment program it has made it possible to obtain apparatus which gears in nicely with the current emphasis upon personal participation in meaningful research as an integral part of the instructional program. A grant from NSF, when matched with an equal sum of money by the trustees of Oberlin College, permitted us to purchase $25,000 worth of apparatus which has given us a real boost in meeting modern needs for superior education in the sciences.

3. Through grants made to certain disciplines which wish to make a comprehensive self-study of means of improving instruction at both the high school and college level a great deal has been learned about how to upgrade teaching procedures.

4. Through institutes for high school and college teachers it has helped retrain those teachers who, through no fault of their own, have become somewhat rusty. Although it is difficult to measure the impact of this kind of a program I am confident that thousands of students are receiving better instruction as a result of this kind of program.

For these reason I am persuaded that NSF has made a real difference and that the difference is all for the good.

Sincerely,

RALPH H. TURNER, *Chairman.*

OBERLIN COLLEGE,
June 1, 1965.

Interoffice to: Fred Foreman.
From: J. L. Powell.
Subject: National Science Foundation.

DEAR FRED: These remarks are in response to the letter you received from Representative Mosher asking for suggestions concerning the NSF.

The importance of the Foundation to science in the United States cannot be overemphasized. Basic research in this country depends on the continued existence and expansion of the Foundation. I feel that all too often, the importance of basic research is judged more on the titles of present research projects than on the long-range benefits of such projects. It seems to me that the basic philosophy of Government support of basic research ought to be a realization that basic research yields benefits which are very often not foreseen when the research begins. There are countless examples which prove that this is the case.

Now a word about the significance of the NSF to science departments at small liberal arts colleges such as Oberlin. Such institutions by virtue of their size and educational philosophy do not have the funds available for the support of the sciences that the large universities with graduate schools have. On the other hand, most scientists, and I include all teachers of science, are and should be interested in doing research. I believe that research and the proper teaching of science are not only compatible but that research is necessary for the best teaching of science. The small colleges, then, should be trying to attract scientists who are oriented toward research as well as teaching. Yet the costs of scientific research are mounting, and this is nowhere better shown than in our field of geology where geologists have now begun to use such instruments as mass spectrometers, electron probes, and computers. This tends to direct the best scientists toward the larger institutions where more funds for research are available. It is at this point that the Foundation becomes important, because it represents a source of funds for the support of science that is available to the large and small institution alike. Were it not for the Foundation and other Government organizations such as AEC and NIH, basic scientific research at small institutions would in my opinion rapidly dwindle away and almost become nonexistent. Certainly the small institutions would not be able to attract scientists interested in both research and teaching.

Using my own case as a rather typical example, when I left graduate school I knew quite definitely that I wanted to do research in isotope geology with a mass spectrometer, and that I liked the small college atmosphere. A person in my position at that time would probably not have come to Oberlin if there had been no possibility of financial support in research from the NSF.

All of this makes clear the importance of the Foundation to science at institutions such as Oberlin. My only criticism of the Foundation is that in the past it has perhaps tended to aid the larger and more wealthy schools proportionately more than the smaller schools, and that it may have concentrated its support on the east and west coasts. I believe it is vital that the Foundation be expanded, and that it give increasing attention to a more equal distribution of its funds, both on the basis of geography and on the basis of the size and quality of the institution seeking funds. I am aware that steps in this direction have been taken recently by the Foundation, but I urge that these steps be continued and furthered.

Sincerely yours,

JAMES L. POWELL,
Assistant Professor of Geology.

OBERLIN COLLEGE,
DEPARTMENT OF GEOLOGY,
Oberlin, Ohio, June 3, 1965.

Hon. CHARLES A. MOSHER,
House of Representatives, Washington, D.C.

DEAR CHARLES: Your letter of the 21st came at a busy time but am very pleased that you have given the staff a chance to present their views on the NSF and its importance to basic science in an undergraduate college. Enclosed are the reports of Dr. William A. Gordon, paleontologist and Dr. James L. Powell, geochemist, the other two teaching members of our staff.

Next year is my last year of teaching at Oberlin and my viewpoint may be a bit different income respects to my young colleagues.

We, Mrs. Kathryn Clisby and I, have had faculty grants from the Earth Science Division of the NSF since it started in 1956. In fact it is, I understand, through Dr. Paul B. Sears and his interest in our work on the pleistocene sediments and their pollen that the Earth Science Division was initiated. These last 2 years geology has had grants from the NSF for undergraduate research. For the next 2 years we have both an undergraduate research participation and also an undergraduate instructional scientific grant. These grants will be of great help to the students and to the geology department.

Students will be given a chance at the undergraduate level to start research under good supervision. An early introduction to research will help to eliminate those who do not have an aptitude for it and encourage and give direction and impetus to those who find it stimulating and rewarding.

The staff too will be encouraged to continue in active research and this I think and hope will help teach in the department as well as benefit those engaged in research and also add to the basic knowledge in the science itself.

There are two problems that will need to be watched. Too much emphasis on research may lead to less interest and time given to teaching. This is already a problem in the graduate schools and may become one in the colleges. If this happened it would be most unfortunate for the students, the colleges, and the country itself.

The other problem is one that has impressed itself on me this last year or so and it is relative to sophisticated instrumentation. These require a lot of attention at the technical level. Many good men who have the mental ability and push for research do not have the skills needed to keep these machines running efficiently and accurately, those that do find this work very time consuming. The universities have skilled technicians but even a relatively rich school like Oberlin does not supply such help. I do not know what the answer to this problem is but it is there.

I hope the above and the letters from my colleagues are of help to you and the Daddario subcommittee.

Sincerely,

FRED FOREMAN, *Chairman.*

ROOSEVELT UNIVERSITY,
OFFICE OF THE PRESIDENT,
Chicago, Ill., June 7, 1965.

Hon. EMILIO QUINCY DADDARIO,
Subcommittee Chairman, Committee on Science and Astronautics,
House Office Building, Washington, D.C.

DEAR MR. DADDARIO: I concur completely with Professor Guthmann's analysis of the benefits to Roosevelt University of the National Science Foundation's program. The enthusiasm generated by the grant awarded to the chemistry department has stimulated other departments of the university as well.

It is particularly in connection with schools like ours, not blessed with large endowments, that the impact of this program becomes especially significant. We would hope that your committee considers it appropriate to emphasize the undergraduate aspects of this program for the benefit of the many liberal arts colleges who turn out the majority of the students going on to graduate work in science. Stimulation afforded in this area would insure the flow of scientifically trained personnel where it is most needed on the graduate level.

Respectfully yours,

ROLF A. WEIL, *Acting President.*

ROOSEVELT UNIVERSITY,
DEPARTMENT OF CHEMISTRY,
Chicago, Ill., June 7, 1965.

Representative EMILIO Q. DADDARIO,
Subcommittee Chairman, Committee on Science and Astronautics,
New House Office Building, Washington, D.C.

DEAR CONGRESSMAN DADDARIO: It is our understanding that your committee is looking into the operation of the National Science Foundation.

It might be of interest to you to know of one of the concrete benefits Roosevelt University has realized from the National Science Foundation. I speak, in particular, of the undergraduate research project. We have had one such grant and have found that the enthusiasm that generated in the three students who participated extended to other students as well and the idea that they would be able to apply some of the chemistry that they had been learning as undergraduates was most significant to them. All three of the students involved are now accepted at graduate schools.

I think the point we would like most to make is that research not only accomplished its own ends but served as a means of sharpening the talents of the students involved prior to their commitment to graduate school. This, in itself, we believe could be a significant contribution to this program. We do hope that your committee will see fit to encourage these aspects particularly.

Another program in which we have been involved, and which we believe should also be enthusiastically supported, is the program involving the upgrading of high school teachers to institutes. We have an in-service institute and have had an opportunity to notice the great need for further training in chemistry for teachers who are currently teaching chemistry. This, too, is a program which needs support and encouragement.

Respectfully yours,

WALTER S. GUTHMANN,
Acting Chairman.

ROCHESTER, N.Y., *June 7, 1965.*

Representative EMILIO Q. DADDARIO,
Congress of the United States,
Washington, D.C.

DEAR REPRESENTATIVE DADDARIO: Because of your considerable knowledge and effort in the critical field of review looking into the relation of fundamental research and public funding I would like to submit for your consideration the copy of a letter to Senator Case, of New Jersey.

Many of us feel strongly, with deep apprehension of the impact on education and welfare, about this issue. We should greatly value your inspection and support of the ideas presented and the many people we believe are sharing these feelings of concern.

Sincerely,

NORBERT J. KREIDL,
Professor of Ceramics,
Rutgers State University.

OBERLIN COLLEGE,
DEPARTMENT OF BIOLOGY,
Oberlin, Ohio, June 9, 1965.

Hon. CHARLES A. MOSHER,
Longworth Building, Washington, D.C.

DEAR CHUCK: You may be assured I gave your letter of May 21 relating to your membership on the Daddario subcommittee and the projected investigation of the Natioinal Science Foundation the attention it deserved. We discussed the letter in staff meeting. Incidentally all were pleased that you were on this committee.

I, myself, do not have any particular wisdom to send you relating to present policies of the National Science Foundation. George Langeler mentioned that it had come to his attention that there was some feeling in the National Science Foundation that project basic research grants should be awarded on a matching basis with a cash contribution coming from the institution. This would put terrible strain on the smaller institutions who have a very difficult time meeting the academic budget to say nothing about sponsored research to benefit the scholarly development of the faculty. George promised that he would write

you in more detail about it when he was sure of his facts. This is something you might keep in mind, however.

Highest regards.

GEORGE T. SCOTT, *Chairman.*

OBERLIN COLLEGE,
DEPARTMENT OF CHEMISTRY,
Oberlin, Ohio, June 11, 1965.

Hon. CHARLES A. MOSHER,
Longworth Building, Washington, D.C.

DEAR CHUCK: Thank you for your invitation to comment on the National Science Foundation. We discussed it in a departmental meeting and have been in surprisingly good agreement.

The programs and policies of the National Science Foundation has evolved over the years in a constructive way. It has initiated and explored new programs and has shown itself responsive to changing needs. The Foundation has modified its procedures as experience indicated. It has kept its principal goals in sight and has held recipients of grants to the objectives of the grants, but it has also encouraged flexibility and experimentation in procedures for reaching goals.

The major moves of the Foundation have been appropriate ones. Some in our department might favor more rapid changes in focus of the programs but all of us agree that the moves of the Foundation have been in the right directions. Several have suggested that what the Foundation needs most is more money, since the Foundation has an impressive history of achievement.

Sincerely yours,

L. E. STEINER, *Chairman.*

[Telegrams]

GAINESVILLE, FLA., *June 22, 1965.*

EMILIO Q. DADDARIO,
Subcommittee on Science, Research, and Development,
House of Representatives, Washington, D.C.:

The National Science Foundation has been doing a very effective job in administering research funds in mathematics aimed toward the graduate education of critically needed mathematicians and applied mathematicians. I commend them for the particular way they are now operating.

JOHN E. MAXFIELD,
Chairman, Department of Mathematics,
University of Florida.

TALLAHASSEE, FLA., *June 24, 1965.*

Hon. E. Q. DADDARIO,
House of Representatives, Science and Astronautics Committee,
Washington, D.C.

Education of mathematicians and applied mathematicians sorely curtailed by lack of funds for research support.

O. G. HARROLD,
Chairman, Department of Mathematics,
Florida State University.

NEW MEXICO STATE UNIVERSITY,
COLLEGE OF ARTS AND SCIENCES,
University Park, N. Mex., June 28, 1965.

Representative E. Q. DADDARIO,
House Office Building, Washington, D.C.

DEAR SIR: I hope you do not receive this letter as if it were an ordinary petition, signed by people who like to have their names on petitions. It is, rather, a letter which we are sending to express our common concern about the relationship between the National Science Foundation and the scientific community.

In your present investigation of the Foundation, we want you to know of our confidence in that organization and in the officials who are charged with its management. And we speak from experience, for each of us has worked with the Foundation, our total experience as a group involving research contracts, fellowships, educational grants, summer and winter institutes at all levels, advisory committees to the Foundation, etc.

We wish to stress the importance of scientific research and what that research can do for our society. In education and in research, it is a necessity—not a convenience—to be able to pursue one's work with a large amount of freedom. Unduly restrictive barriers, financial or otherwise, can inhibit creative inquiry.

The National Science Foundation is managed by people who understand this. While we know that your inquiry will be conducted in all fairness, and while we understand very well the duty Congress has to regulate Government agencies, we hope that the National Science Foundation may continue to be trusted to further the cause of science without any new restrictive laws, regulations, or procedures.

Sincerely yours,

Robert J. Wisner, Associate Professor of Mathematics; Paul K. Garlick, NSF Fellow; J. Mack Adams, Assistance Professor of Mathematics; Franklin D. Rich, NSF Institute Instructor; Jack R. Porter, NSF Fellow; Carol L. Walker, Assistant Professor of Mathematics; Edward D. Gaughan, Assistant Professor of Mathematics; Louis Solomon, Associate Professor of Mathematics; Donald Cook, NSF Institute Instructor; William G. Calton, NSF Fellow; Chiev Khus, NSF Institute Instructor; Larry D. Parker, NSF Fellow; John B. Giever, Professor of Mathematics; Conrad McKnight, NSF Institute Instructor; John D. Thomas, Assistant Professor of Mathematics; Elbert A. Walker, Professor of Mathematics.

CHARLOTTESVILLE, VA., *July 12, 1965.*

Hon. EMILIO DADDARIO,
Chairman, House Science Subcommittee,
House Office Building,
Washington, D.C.

DEAR SIR: I saw several announcements recently of your interest in basic research. I was graduated many years ago from MIT and have spent most of the time since then in research and development. I have filed more than 1,000 of my inventions in the Patent Office, in many different fields. I am equally interested in basic research and I have seen many original conceptions of mine later develop into highly important and valuable discoveries. In order to be more specific I am enclosing a list of my issued patents and a partial list of various originations.

My experience with various organizations such as the National Science Foundation, Office of Naval Research, and others convinces me that something is radically wrong in our Government-sponsored research program. Some years ago a person in ONR having charge of granting basic research contracts told me that he could not give me a contract since my proposed research would have practical applications.

If the NSF policy is the same as it was several years ago it badly needs overhauling. They required that the research worker have substantial amounts of laboratory equipment and also access to funds, and other requirements which would completely eliminate many brilliant scientists from participating. Often the more brilliant the scientists the less likely it is that he can meet the hardware and other requirements of the NSF. The contracts should be awarded on the basis of the originality and industriousness of the scientists and not on the amount of bricks and mortar and other equipment which he can corral. A really capable person can do a tremendous amount of basic research with remarkably little equipment. He should be furnished the equipment regardless of whether he is operating independently or is connected with an institution.

Another great weakness of the past policy is the interminable delay between the date of filing a research proposal and the final decision may be a year later. This is due to shipping the proposal all over the country to various "experts" who, in my opinion, cannot collectively come to any wiser decision than a really capable person who could decide in a matter of weeks. It is of vital importance to select very capable people to pass on research proposals and to give them authority to make quick decisions. When one looks at the worthless and sometimes even silly contracts which frequently have been awarded I am convinced that a few well-paid and highly informed specialists in various fields can do a much better and far faster job of selecting really important research projects than has been done under the past system.

I am not now looking for research contracts for reasons which I have indicated. I would, however, like to see our sponsored research set up on a more effective basis because I am certain that it can be done. I have a very large backlog of basic research ideas recorded in my notes and, if my past experience is any guide, quite a few of them will eventually be brought out by someone else, perhaps 10 or 20 years from now. Judging from past experience some of them will be of outstanding importance, but why delay discovery when it is not at all necessary?

I have met some scientists who have developed a certain reputation sometimes based on standards which are not valid. Some of them have much more reputation than originality and the latter is the one indispensable in research. I believe that it is highly important to avoid such people and to turn over the direction of NSF, ONR, and other organizations to people who really understand the creative, highly imaginative type of research worker. There has been a decided dearth of such understanding in the past.

Very truly yours,

A. G. THOMAS.

OBERLIN COLLEGE,
DEPARTMENT OF PHYSICS,
Oberlin, Ohio, July 26, 1965.

Hon. CHARLES A. MOSHER,
House of Representatives, Washington, D.C.

DEAR CHUCK: I am sorry to have put off so long answering your letter about the NSF hearings. What follows is a somewhat random collection of remarks and impressions.

In general, it seems to me that the NSF has done a fine job of providing excellent support for basic science. With the stupendous press agentry of NASA and, to a lesser extent, of the AEC and the NIH, it is remarkable that Congress and the NSF have been able to build up an impressive level of well-administered support. One may quibble over some things—I, for one, would like to see all NSF graduate fellowship winners really free to choose their schools, as opposed to the current situation with the politically expedient "cooperative" fellowships—and there have been one or two bloopers such as the Mohole business and the AIB fuss, but on the whole the record has been impressive.

The "institutional grants for excellence" proposed last year are evidence that that Foundation is seriously concerned about places such as Oberlin and with the up-and-coming State universities. As you know, we have been able to get summer (and some term-time) research participation grants, and matching grants for equipment. At the moment we have hopes of substantial grants for science departments from the Sloan Foundation and from the Research Corp., but, in the long run, support for thriving research and teaching at a place like this will have to come, in large measure, from the NSF. In the last few years, places such as Oberlin have been going through a quiet but far-reaching revolution in the science departments. Even so, we cannot now, nor are we likely to be able to, compete for NSF money on the same terms as Harvard, Case, MIT, or even Ohio State. Therefore I hope the various programs within the NSF aimed at promoting good science at smaller places will be continued and strengthened. I hope that Trustee Mosher will urge Congressman Mosher to press for more outright grants as opposed to matching grants.

I am enclosing some Xerox copies of some "News and comments" sections from Science, the weekly journal of the American Association for the Advancement of Science. Greenberg, Walsh, and the others who write that column seem to me to be both politically astute and scientifically aware. They do a fine job of interpreting the political pressures to us scientists in the hinterlands, and I suspect that you and your colleagues might find occasionally illuminating pieces there as well. No doubt the last thing in the world you want at this point is a suggestion that you subscribe to one more periodical, but perhaps one of your minions in your efficient office could scan each week's copy for interesting articles as well as for significant items in the "news and comment" section. If you wish, I could attempt something of the sort here—sending copies of likely material—but it might be somewhat faster if done in your own office.

I'm not at all sure that any of this has been of any help to you, but I appreciate your taking the time to get opinions from chairmen of the science departments here.

With best wishes,

DAVID L. ANDERSON, *Chairman.*

UNIVERSITY OF ILLINOIS,
Urbana, Ill., July 29, 1965.

Mr. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, Rayburn House Office Building, Washington, D.C.

DEAR MR. DADDARIO: From a number of sources I have learned of your subcommittee's consideration of the activities of the National Science Foundation over the past 15 years, and of the informed and sympathetic attention you have given to the role of the social sciences in the Foundation's work. As an anthropologist dedicated to the study of the mystery that is man, I find this especially heartening. As you know, anthropology has enjoyed the support of the Foundation almost since its establishment, and I believe my colleagues around the country would agree that this has been a crucial factor in the rapid growth and maturation of the discipline during the past 15 years. The future of my own field as well as that of our sister disciplines in the other social sciences depends in large measure on the continued and increased support of the Foundation. Thus, I cannot but applaud congressional concern to understand both the nature and the needs of the social sciences.

I might add that during 7 years of residence in Washington, from 1950 to 1957, and after that period as well, I have followed closely the fate of the Foundation, and particularly the growth of the social sciences in its work. I have also served on the Advisory Panel in Anthropology and on numerous ad hoc committees. This total experience has convinced me that the Foundation and the able men who serve it is the most vital and catalytic scientific institution in the Nation. It can and should serve increasingly well all the sciences, including those whose concern is man himself.

Sincerely,

JOSEPH B. CASAGRANDE,
Head, Department of Anthropology.

SWARTHMORE COLLEGE,
DEPARTMENT OF POLITICAL SCIENCE,
Swarthmore, Pa., July 29, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, Rayburn House Office Building, Washington, D.C.

DEAR CONGRESSMAN DADDARIO: I note with interest that your subcommittee of the Committee on Science and Astronautics, in reviewing the work of the National Science Foundation, has been giving some attention to the needs of the social sciences. Feeling as I do that these areas of research and study have tremendously important contributions to make to the national welfare, I am delighted that you are giving sympathetic attention to their problems.

Sincerely yours,

J. ROLAND PENNOCK, *Chairman.*

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, D.C., July 29, 1965.

Hon. EMILIO DADDARIO,
Chairman, Science, Research, and Development Subcommittee, Science and Astronautics Committee, House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I believe that it is necessary that the National Science Foundation should change its policy and provide more grants to the social sciences.

I am fully aware that the National Science Foundation has done fine and constructive work; however, I strongly believe and urge that more grants should be issued by the National Science Foundation in the field of social sciences, such as economics, sociology, political science, and others. (This is not meant to refer to the arts and humanities, including art, music and literature, which are provided for in the National Arts and Humanities Foundation bill.)

I was surprised and dismayed to discover that in the list of NSF fellowship programs, there are 103 fields of specialization in engineering, physical, psychological, life, and medical and mathematical sciences, but only 10 in the social sciences. I believe that the social science fellowship grants should be at least doubled by the National Science Foundation—from 10 to 20 percent. Certainly

the 103 subjects are very valuable to our Nation, but other fields are also important—one of them being the social sciences. In addition, I believe that research grants should be substantially increased by NSF in social science subjects. This increase should not be made at the price of other fields, but provided by higher Federal appropriations.

Certainly, a great deal of good would result from such a revision, in economics, sociology, and political science—some of the social sciences.

So many Americans lack even a basic understanding of economics, a field that affects all of us very much. Just think of the broad and tremendous affect these programs have on our daily lives: Taxes, Federal spending, foreign aid and balance of payments. The Kennedy round on tariffs will take place in September and will have a heavy impact on our economy in the vital areas of imports and exports. But how many people understand this program?

Another area in the field of economics that more people should understand is the surplus farm products problem. Still another is the effect of more people leaving the farms for urban and suburban areas.

Another vital area that requires increased attention is sociology—the study of human groups. As our society becomes more complex, greater study is necessary of man and his problems. Above all, practical solutions must be found.

There is also a very definite need for more knowledge and understanding in the field of political science. Our citizens should be aware of how our Government functions and what its problems and goals are. With increased knowledge, they could improve Government.

I must say that the National Science Foundation does help many. Since January 1963, when I assumed office, Rutgers—the State university has received $5,910,726 in NSF grants. These grants have provided great help to scientific and technical projects, as well as aiding our teachers by special training.

I appreciate any considerations you may give these views. Thank you very much for your cooperation in this matter.

Best personal regards.

Cordially yours,

EDWARD J. PATTEN.

UNIVERSITY OF WISCONSIN,
DEPARTMENT OF SOCIOLOGY,
Madison, Wis., August 2, 1965.

Hon. EMILIO Q. DADDARIO,
Subcommittee on Science, Research, and Development, House Committee on Science and Astronautics, Rayburn House Office Building, Washington, D.C.

DEAR CONGRESSMAN DADDARIO: I am on the Board of Directors of the Social Science Research Council, and I am therefore very interested in your committee's review of the National Science Foundation. It happens that I just received a 3-year grant from that agency for a study of American urban history.

I would like you to know that I regard the NSF program as the most significant source of support for the advancement of social science research. It has initiated the best work in the field, and the work done under its auspices is of very high quality. I urge you to take account of these important facts in your deliberations.

With best wishes for a successful inquiry, I remain,

Sincerely,

LEO F. SCHNORE,
Professor of Sociology.

UNIVERSITY OF ROCHESTER,
DEPARTMENT OF PHYSIOLOGY,
SCHOOL OF MEDICINE AND DENTISTRY,
Rochester, N.Y., August 2, 1965.

Hon. E. Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, House of Representatives, Washington, D.C.

DEAR MR. DADDARIO: I have read with considerable interest the statement of Dr. Alvin M. Weinberg before your committee on July 8 on "the future role of the National Science Foundation." I am a member of the community of biological sciences in this country, and also a member of the Divisional Com-

mittee for Biological and Medical Sciences of the National Science Foundation. I was particularly concerned with one aspect of Dr. Weinberg's statement, and that is his recommendation that all of the Government support for the biological sciences be placed under the National Institutes of Health. This would mean that the National Science Foundation would become an agency solely concerned with the physical sciences. I would like to vigorously counter this viewpoint by saying that I think it would be most unfortunate to remove any support for the biological and medical sciences from the National Science Foundation as it is now constituted. I think it is a healthy thing to have diversity of support for scientific research within the Government. Secondly, the uniqueness of the support for biology in the National Science Foundation derives from the fact that it covers all branches of the biological sciences, not just those related to health as in the case of the National Institutes of Health. The National Institutes of Health is already a rather monolithic structure, and I feel that it would be a mistake to increase this by giving it responsibility for all biological sciences' support. I sincerely hope that Dr. Weinberg's ideas will not be adopted and that the division of medicine in the biological sciences will not only remain in the National Science Foundation but will be strengthened.

Sincerely yours,

WILLIAM D. LOTSPEICH, M.D., *Chairman.*

UNIVERSITY OF ROCHESTER,
SCHOOL OF MEDICINE AND DENTISTRY,
DEPARTMENT OF PHYSIOLOGY,
Rochester, N.Y., August 3, 1965.

HON. CHARLES A. MOSHER,
Subcommittee on Science, Research, and Development,
House of Representatives,
Washington, D.C.

DEAR MR. MOSHER: I have read with considerable interest the statement of Dr. Alvin M. Weinberg before your committee on July 8 on "The future role of the National Science Foundation." I am a member of the community of biological sciences in this country, and also a member of the Divisional Committee for Biological and Medical Sciences of the National Science Foundation. I was particularly concerned with one aspect of Dr. Weinberg's statement, and this is his recommendation that all of the Government support for the biological sciences be placed under the National Institutes of Health. This would mean that the National Science Foundation would become an agency solely concerned with the physical sciences. I would like to vigorously counter this viewpoint by saying that I think it would be most unfortunate to remove any support for the biological and medical sciences from the National Science Foundation as it is now constituted. I think it is a healthy thing to have diversity of support for scientific research within the Government. Secondly, the uniqueness of the support for biology in the National Science Foundation derives from the fact that it covers all branches of the biological sciences, not just those related to health as in the case of the National Institutes of Health. The National Institutes of Health is already a rather monolithic structure, and I feel that it would be a mistake to increase this by giving it responsibility for all biological sciences' support. I sincerely hope that Dr. Weinberg's ideas will not be adopted and that the Division of Medicine in the Biological Sciences will not only remain in the National Science Foundation but will be strengthened.

Sincerely yours,

WILLIAM D. LOTSPEICH, M.D., *Chairman.*

UNIVERSITY OF CALIFORNIA, BERKELEY,
DEPARTMENT OF ECONOMICS,
Berkeley, Calif., August 5, 1965.

Congressman JEFFERY COHELAN,
House of Representatives,
Washington, D.C.

DEAR JEFF: It has come to my attention that the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics is now undertaking a review of the National Science Foundation. I am very much interested in the development of NSF, and especially in the role which the

social sciences (in my case, particularly economics) have played in the work of the Foundation.

I think there is growing recognition in government, among physical scientists, and certainly within NSF, that research and training in the social sciences thoroughly deserve governmental support, and that the moderate investment that NSF has thus far made in the social sciences has been well spent.

To the extent that it is convenient for you to bring these sentiments to the attention of members of the subcommittee (I believe Representative Daddario is chairman), I should be very grateful. I am enclosing an additional copy of this letter if you would care to transmit it to him * * *.

Cordially,

R. A. GORDON,
Chairman, Graduate Committee, Professor of Economics.

UNIVERSITY OF MINNESOTA,
OFFICE OF THE DEAN,
Minneapolis, Minn., August 5, 1965.

Hon. JOSEPH KARTH,
House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN KARTH: It has just come to my attention that, during the hearings of the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics, there has been direct consideration and considerable friendly concern about the social sciences.

Under the circumstances, I cannot resist writing you with a couple of observations. First, I have been very much pleased by the increasing entry of the National Science Foundation into the support of the social sciences. I think it is fair to say that my colleagues on every side of the university would agree to the importance of support of scientific study of the economic, social, geographical, and historical dimensions of man's activities. Second, I have been most impressed and gratified by the manner in which the National Science Foundation has supported scientific study of locational patterns of resources and human settlements, as well as institutes for the upgrading of researchers and of college and school teachers, in my own field of geography.

Although the word may not reach you very often, you should know that these efforts are appreciated and are being used to the utmost of their ability by the scientists and the disciplines concerned.

Best personal regards.

Sincerely,

JOHN R. BORCHERT,
Associate Dean and Professor of Geography.

UNIVERSITY OF PENNSYLVANIA,
WHARTON SCHOOL OF FINANCE AND COMMERCE,
Philadelphia, Pa., August 13, 1965.

Congressman EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, Committee on Science and Astronautics, Rayburn House Office Building, Washington, D.C.

DEAR CONGRESSSMAN DADDARIO: I was pleased and encouraged to learn of the interest your subcommittee has recently shown in the social sciences. During the past 2 years, I have had the opportunity to serve as consultant to the National Science Foundation, on the Advisory Panel for Economics. I was greatly impressed by the high quality, integrity, and dedication of the staff members with whom I came in contact.

All around us are urgent social problems—international political conflict, racial strife, poverty, unemployment—requiring, in the interest of our own self-preservation, objective and scientific analysis. Yet the resources so far devoted to such work seem to me discouragingly small in relation to the need. Anything your committee may do to further social science study and research would, I believe, be of the utmost value.

Sincerely,

RICHARD A. EASTERLIN, *Professor of Economics.*

YALE UNIVERSITY,
New Haven, Conn., August 18, 1965.

Hon. EMILIO Q. DADDARIO,
House of Representatives,
Washington, D.C.

DEAR MR. DADDARIO: On July 8, 1965, Dr. Alvin M. Weinberg presented to your Subcommittee on Science, Research, and Development a statement entitled "The Future Role of NSF." This statement has been circulated and I would like to comment upon certain of the points made by Dr. Weinberg.

As a biologist who has conducted research with the aid of both NSF and NIH grants and as a member of one of the NSF advisory panels, I have had opportunities to observe and to participate in various aspects of the support of university-based biology by the Federal granting agencies.

With most of Dr. Weinberg's comments I am in complete and hearty agreement. The future will be the age of biology in large part because the physical scientists have been so impressively successful in the solution of their problems, many of which are vitally pertinent to biology. All biologists will agree with Dr. Weinberg that support for the physical sciences must continue and that the support of medical research should be greatly increased.

There is really only one point at which I depart from agreement with Dr. Weinberg's highly competent analysis. That concerns the linking of biology and medicine and the suggestion that all, or most, biological research should be supported through NIH. The difficulty is simply that, as Dr. Weinberg points out, NIH is a "mission oriented" agency and not all, or even most, of biology is so oriented. Biology and medicine are, of course, intimately related but they are not complete synonyms and "biomedical" is not the same thing as "biological." If all support for biology were to be through NIH the result could easily be the exclusion from support of much of the basic biology now receiving at least modest support through NSF. I do not believe that Dr. Weinberg intends that this should occur and he does note that NSF should retain some responsibility for sciences other than the physical sciences, "especially in the universities." Perhaps this answers my question but I am still wary of the linking of a major part of basic biology to a mission-oriented agency.

The danger I see in the adoption of Dr. Weinberg's suggestion is not in the idea itself but in the easily predictable way in which it would be carried out by a mission-oriented agency. Because of the pressures which are brought to bear on such agencies (and not only by congressional committees) there is an understandable tendency to support only those projects which have direct "practical" value easily understood by everyone. As some Congressman recently said, "Don't tell me about hybrid corn again"—so I'm not going to offer any hackneyed arguments about "basic" versus "applied" research. I do hope however that it will be kept in mind that there is a great deal of biology that is not necessarily or directly related to medicine, agriculture, or other obviously applied areas but which is still deserving of support.

The National Science Foundation could undoubtedly be improved but it is highly doubtful that taking away most of its responsibility for the support of the biological sciences will improve either the NSF or biology.

Respectfully yours,

CHARLES G. SIBLEY,
Professor of Biology and Curator of Vertebrate Zoology.

NATIONAL ACADEMY OF ENGINEERING,
OFFICE OF THE PRESIDENT,
Washington, D.C., August 18, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development,
Committee on Science and Astronautics,
Rayburn House Office Building, Washington, D.C.

DEAR REPRESENTATIVE DADDARIO: Since testifying before your committee on July 15, I have received certain data regarding engineering fellowships from Dr. Leland J. Haworth, in a letter which he wrote me on August 6, a copy of which was sent to your committee. In my testimony I stated that the engineering profession felt that there was a "woeful lack of national science fellowships in engineering." Dr. Haworth's letter shows that this may not be justified, and is not consistent with the facts pertaining to the relative number of awards

in engineering and various branches of science over the years. His letter further shows that performace has been particularly favorable to engineering in fiscal 1965.

In my testimony I mentioned the subject of education in passing, as it were, and specifically suggested that facts pertaining thereto should come from those in the educational world. This letter is being written to put that part of my testimony in the proper context.

May I again express my appreciation of the constructive spirit with which you are handling these hearings.

Respectfully,

AUGUSTUS B. KINZEL.

UNIVERSITY OF CHICAGO,
DEPARTMENT OF GEOGRAPHY,
Chicago, Ill., August 18, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, Committee on Science and Astronautics, Rayburn House Office Building, Washington, D.C.

DEAR MR. DADDARIO: In connection with your review of the National Science Foundation you may have some interest in foreign governmental provision for support of sciences. My own information is limited to geography and some of the other social sciences, but I have noticed the following general features:

(1) All the foreign equivalents of our National Science Foundation make provision for including the whole range of the sciences—physical, biological, and social—though in varying propositions.

(2) The method of support varies between two general patterns:

(*a*) in Eastern European countries, in general, the academies of science or research supporting organization tend to establish independent research units separate from universities but part of the academies of science themselves. This is true, for example, of the Akademiia Nauk in the U.S.S.R., the Ceskoslovenská Akademie Věd and the Slovenská Akadémia Vied in Czechoslovakia, of the Magyr Tudományos Akadémia in Hungary, of the Academia Republicii Populare Romíne in Rumania, and of the Bŭlgarska Akademija na Naukite in Bulgaria, but only partly the case with the Polska Akademia Nauk in Poland. What is characteristic of each of these mechanisms for national governmental support of science of all types is the rapid rise in level of support as a basic feature of national policy, which considers such expenditures as productive investments which will pay high dividends in the advancement of the economy and society of these countries.

(*b*) in Western and southern European countries the typical pattern is a science foundation or academy which makes grants to existing institutions (mostly universities or institutes in universities). This tends to be true for example of the Deutsche Forschung gemeinschaft in the German Federal Republic, or of the Centre National de la Recherce Scientifique in France, or the Consiglio Nazionale delle Ricerche in Italy, or the Consejo Superior de Investigaciones Cientificas in Spain.

I have been struck by the high quality and importance of work supported by our own National Science Foundation in recent years.

Yours sincerely,

CHAUNCY D. HARRIS, *Professor of Geography.*

HARVARD UNIVERSITY,
CENTER FOR INTERNATIONAL AFFAIRS,
Cambridge, Mass., August 20, 1965.

Congressman EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development,
House of Representatives, Washington, D.C.

DEAR MR. DADDARIO: I have heard from Dr. Pendleton Herring, the president of the Social Science Research Council, of the sympathetic interest in the social sciences manifested by you and the members of the Subcommittee on Science, Research, and Development during recent hearings in Washington on the legislation concerning the National Science Foundation. The reception given to the social sciences in Washington is not always friendly, indeed it is often hostile, and, more serious, based on profound misunderstanding of their organization, values, and purposes. This makes it particularly refreshing and promising to

learn that in your subcommittee a more enlightened attitude apparently prevails.

As one who for many years served as a social science analyst in Washington, and since then worked intimately with defense agencies, the Department of State, and the welfare agencies of the Government in various social science projects, I can testify that social science has a vital role to play in the affairs of our Government. More basic, I believe that it has a crucial place in the pattern of American life. The great sociologist Durkheim said long ago that only a truly free society could tolerate and would support the social sciences. The way in which those disciplines flourish in the United States, and either languish or even are forbidden in Soviet Russia and Communist China, lends support to this dictum. Without in any sense wishing to put myself in the position of a special pleader for the interests of my own field, I do hope that in the legislation on the NSF you will find a way to give the social sciences their proper and just place among the sciences which man honors because they honor him.

Sincerely yours,

ALEX INKELES,
Professor of Sociology.

PENNSYLVANIA STATE UNIVERSITY,
OFFICE OF THE PRESIDENT,
University Park, Pa., August 24, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development,
House of Representatives, Washington, D.C.

DEAR CONGRESSMAN DADDARIO: I am writing to you at the suggestion of Mr. George A. Whittington, editor of Research and Development magazine. Mr. Whittington heard a presentation of our report on "Continuing Professional Educational Needs of Engineers" at an R.&D. seminar at our university and urged that I communicate this information for consideration by your Subcommittee on Science, Research, and Development.

The Methods Research Division, Continuing Education, the Pennsylvania State University, has just completed a study on the updating needs of 2,090 engineers who have been working in industry for at least 5 years.

The study provides comprehensive, quantitative data on the updating needs of engineers in the basic sciences, engineering sciences, the applied aspects of engineering, management areas, and the social science and humanities educational needs.

To reduce the problem of obsolescence, it is urgent that engineers and scientists be kept abreast of newly developed information. Our study provides evidence of the importance of the problem and the critical need to intensify the development of policies to meet these technological needs.

Enclosed is a copy of "Highlights," a brief summary of the study, and a copy of the research report. Should your committee require additional data from the other reports stemming from our project, we will be glad to furnish them to you.

If I can be of further assistance to you, please do not hesitate to write me.

Sincerely yours,

ERIC A. WALKER, *President.*

[From "Highlights," Pennsylvania State University, Continuing Education]

A SURVEY OF CONTINUING PROFESSIONAL EDUCATION FOR ENGINEERS IN PENNSYLVANIA

(By Samuel S. Dubin, Ph. D., LeRoy Marlow, D. Ed.)

PREFACE

Few issues of current technical publications appear without some reference to the exponential growth of knowledge and the obsolescence of engineers. Much talk, many words, and some individual case studies are on record, but there has been a dearth of factual information.

The Pennsylvania State University desired to assess the extent and magnitude of the problem before formulating plans to meet these needs. The "Survey of Continuing Professional Education for Engineers in Pennsylvania" was limited to the self-determined needs of engineers employed in various positions in Pennsylvania.

A sample of 2,090 practicing engineers was carefully selected so as to be representative of the number of engineers in Pennsylvania in each industrial category, covering companies of all sizes and including engineers at various levels of responsibility and of all age groups, but excluding those who had received their B.S. degrees within the preceding 5 years. For the first time, to my knowledge, statisticaly signficant data are available from which to draw conclusions.

Action to meet these now-determined professional needs in the Commonwealth is of paramount importance. Areas of great need have been indicated as a result of actual survey rather than a conclusion masterminded by either the local demands of industry or the surmise of the academics.

It seems clear that practicing engineers themselves recognize the need for further study. Respondents indicate that they would take further work, if available, not only in technical but also in managerial and social-humanistic studies for improvement of both their professional skills and general education.

Imparting knowledge is by no means an exclusive prerogative of universities. Practicing engineers can learn from many sources and many experiences, but educational institutions have traditionally been looked to as sources of additional knowledge. Presumably, we in the universities and colleges not only know how to teach but also recognize and can enforce the rigorous and high standards needed to insure that time spent in study will be worthwhile. Financial means must be found to prepare and to offer up-to-date instruction in the selected fields where the demand is widespread if we are to make the best use of our professional personnel in the technological and managerial areas.

HIGHLIGHTS OF SURVEY RESULTS

This report is a condensation of the survey "Continuing Professional Education for Engineers in Pennsylvania" and includes the objectives, scope, and methods used; a justification of the project; highlights of the results; and the recommendations.

Objectives of the survey

1. To determine the self-perceived educational needs for engineers who have been out of college 5 or more year.
2. To determine attitudes of engineers toward continuing education needs as related to their job, supervision, and company.
3. To recommend methods for providing continuing education programs to update engineers.

Scope of the survey

Two methods were used:

1. A written questionnaire was completed by 2,090 engineers in 171 industrial and 4 governmental organizations. It was composed of four parts: General information, professional education, management education, and social science and humanities.
2. Group interviews were conducted in 51 companies; 408 engineers participated in 123 interviews. The interviews involved engineers who supervise technical operations, direct management activities, and perform technical duties.

Justification for the survey

The conditions which stimulated the undertaking of this survey are—

1. Engineering knowledge and techniques have a rapid technological obsolescence.
2. The growth rate of knowledge is accelerating rapidly.
3. The demand for professionally trained engineers will persist for many years.
4. Strong personal motivation is required for an engineer to remain up to date.
5. The growth rate in research and development programs and expenditures requires constant altertness to current developments in engineering.
6. Industrial processes and products continue to become increasingly complex.

ADDITIONAL REPORTS

The findings from this research project are available in three forms:

1. The "Survey Report" which presents the total findings of the questionnaire and interviews in a condensed form. This report is designed for the lay reader and does not include the research design, procedures, or methodology.

2. A complete "Research Report" which includes all of the information in the "Survey Report" but in greater depth plus an expanded discussion of the background, significance, and methodology of the study.

3. Fifty-three "Engineering Education Research Reports" which present data pertinent to industrial groups, major fields of engineering, State geographical locations, registered professional engineers, time in profession, course needs, and related information. Titles listed below:

ENGINEERING FIELDS

Number	Title
E 1	Chemical
E 2	Civil
E 3	Electrical—Electronics
E 4	Electrical—Power
E 5	Engineering—General
E 6	Industrial
E 7	Mechanical
E 8	Metallurgical
E 9	Mining

INDUSTRIAL GROUPS

E 10	Aircraft, Motors and Parts Industry
E 11	Chemical and Allied Industry
E 12	Electrical Machinery and Equipment Industry
E 13	Machinery Industry
E 14	Mining Industry
E 15	Paper and Allied Industry
E 16	Petroleum Refining Industry
E 17	Primary Metal Industry
E 18	Professional, Scientific & Controlling Instruments Industry
E 19	Research and Consulting Laboratories Industry
E 20	Transportation Industry
E 21	Electric Utilities Industry
E 22	Gas Utilities Industry
E 23	Telephone & Telegraph Companies Industries
E 24	Water Utilities Industry
E 53	Construction Industry

STATE GOVERNMENT

E 25	State Government Engineering Employees

GEOGRAPHICAL DISTRICTS

Number	Title
E 26	Allentown Area
E 27	Altoona Area
E 28	Erie Area
E 29	Harrisburg Area
E 30	Pittsburgh Area
E 31	New Castle Area
E 32	New Kensington Area
E 33	Philadelphia Area
E 34	Williamsport Area
E 35	Wyomissing Area
E 36	York Area

REGISTERED PROFESSIONAL ENGINEERS

E 37	Registered Professional Engineers
E 38	Not Registered Professional Engineers
E 39	P. E. Examination Candidates

YEARS IN PROFESSION

E 40	B.S. Degree in Years 1950–58
E 41	B.S. Degree Prior to 1950

MANAGEMENT

E 42	General
E 43	Personnel
E 44	Financial
E 45	Manufacturing
E 46	Marketing and Sales
E 47	R. & D.

PLANT SIZE

E 48	Plants of 100–499 Employees
E 49	Plants of 500–999 Employees
E 50	Plants of 1,000–4,999 Employees
E 51	Plants of 5,000 or more Employees

NONCREDIT COURSES

E 52	A Tabulation of Noncredit Courses

Engineers reported an interest in the following:

	Percent[1] expressing a need for
1. Technical skills:	
Basic Sciences:	
Probability and statistics	62
Review of college mathematics	53
Review of college physics	48
Calculus	47
Modern algebra	46
Differential equations	43
Modern analysis	43
Modern algebra	43
Statistical inference	42
Engineering sciences:	
Engineering economy	68
Engineering analysis	61
Computer programing, digital	57
Engineering materials metals	55
Computer programing, analog	53
Information data processing	51
Electronics	47
1. Technical skills—Con.	
Engineering sciences—Con.	
Heat transfer	47
Construction materials	45
Engineering materials, plastics	43
Fluid mechanics	42
Stress analysis	41
Corrosion-electrometallurgy	40
Metallurgy	40
Engineering analysis, design and systems:	
Automation	54
Program evaluation and review techniques (PERT)	48
Instrumentation, measurement, and process control	47
Work simplification and measurement	47

See footnote 1, p. 1461.

	Percent[1] expressing a need for
1. Technical skills—Con.	
Engineering analysis, etc.—Con.	
Production management	46
Quality control	43
Systems engineering	41
2. Communication skills:	
Rapid reading	80
Effective communication in organizations	78
Conference leadership	77
Public speaking	76
Oral presentation of statistical and technical reports	74
Technical report writing	74
Business letter writing	70
Listening skills	67
Composition and rhetoric	57
Interviewing skills	53
Engineering graphics	42
3. Managerial skills:	
Job evaluation	68
Human relations skills	61
Business law	57
Man-machine interface (human engineering)	55
Product planning	54
Analyzing organizational effectiveness	53
Budgeting and auditing	51
Understanding individual and group behavior in work situations	47
Supervisory training, employee development	47
Decisionmaking training by use of simulation methods	45
Performance appraisal, coaching techniques	43

	Percent[1] expressing a need for
3. Managerial skills—Con.	
Selection and assessment of personnel	42
Value analysis	41
Information data processing systems for decisionmaking	40
Financial planning and forecasting	40
4. Social sciences and humanities:	
Work related needs:	
Economics	63
Logic	61
English composition	58
Ethics	57
Psychology	53
Community and public relations	50
Leisure time needs:	
Community and public relations	68
Fine arts—music	65
Logic	63
Psychology	62
Literature	61
Religion	61
International understanding	58
Philosophy	58
Economics	55
Ethics	53
Fine arts—theater	52
Political institutions	52
Sociology	48
History	47
Fine arts—art	46
International economics	46
English composition	44
Foreign languages	44
Fine arts—painting	40

[1] Percentages include compined responses of the first two choices from a three-point scale: "Should Have," "Could Use," and "Don't Really Need." Items scoring below 40 percent are not listed. Percentages express degree of need for those answering each item.

5. Postcollegiate degree work:
   6 engineers (0.3 percent of 2,090 engineers) were working on an additional B.S. degree.
   93 engineers (4.4 percent of 2,090 engineers) were working towards a masters degree.
   12 engineers (0.6 percent of 2,090 engineers) were working toward a doctorate.
   Only 4 percent reported that postcollegiate work was required for promotion or salary increase.
   Most frequent reasons for not seeking degree:
   1. Do not have time.
   2. Too far from educational center.
   3. Job does not demand more education.
6. Nondegree work:
   1,183 (58 percent) wanted to enroll in noncredit courses if offered locally.
   1,106 (55 percent) wanted to enroll in advanced credit courses if given locally.

7. Updating methods:

The following sources were used frequently for updating:	Percent using
Scientific-technical journals	50
Manufacturer's literature	35
Technical books and reports	28
Company-industry policies and procedures	29
Business reports	15
Professional society meetings	13

726 (35 percent) of the engineers surveyed participated in no educational activity during the past 4 years.

University day courses were "used frequently" by less than 1 percent (N=15) and university night courses by 6 percent (N=107).

8. Methods preferred for updating (other than formal classroom):	Percent expressing a preference
Correspondence courses	35
Educational television	34
Programed instruction	31

9. Functions and activities:

The most frequently ranked functions and activities were:

Function	Rank [1]	Mean percent of time spent [2]
Administration	1	25
Design	2	24
Development	3	20
Activity		
Conferences	1	7
Correspondence	2	8
Planning and organization	3	13
Supervision	4	22

[1] By frequency of participation.
[2] Rank and mean percent of time spent are independent calculations.

10. Professional development:

1,433 (72 percent) indicated that their company permits in-service training courses to be held on company time.

1,384 (67 percent) believed their company encourages them to enroll for advanced work but 1,683 (81 percent) believed post-collegiate work is not required for promotion or salary increase. An additional 315 (15 percent) did not know whether or not such work is required.

11. Supervisors' attitude toward further education and training: 1,313 (64 percent) reported that their supervisors take a noncommittal attitude to their further education or training.

12. Educational assistance plans:

1,624 (79 percent) of the engineers reported that their companies have an educational assistance program.

1,493 (74 percent) indicated that the availability of a company-paid educational assistance program had no effect on motivating them to undertake educational work.

13. Professional engineering registration:

551 (27 percent) were registered professional engineers.

761 (43 percent) wanted to take a course to prepare them for the professional engineer examination.

585 (33 percent) desired to take the professional engineer examination.

14. Associate degrees: The programs most needed by companies in the opinion of engineers were:

	Combined percent of "would like to have" and "anticipate need" [1]
Computer technology	80
Instrumentation and control technology	78
General engineering technology	74
Electrical and electronic technology	72
Production technology	62
Drafting and design technology	60
Maintenance technology	56

[1] First 2 choices of a 3-point scale.

15. Year of B.S. degree: 1,573 (75 percent) received their B.S. degree between 1949 and 1959.
16. The shift from undergraduate fields of engineering to present work:
Comparison of ranks between undergraduate degree in specific field of engineering with present engineering work shows considerable shifting.
This mobility indicates need for continuing education.
17. Education need and size of company: No relationship was found between size of company and educational need. The updating needs of engineers were similar for all sizes of companies except on selected items. These exceptional differences existed only in the very large companies.

RECOMMENDATIONS

For the university

1. The university should assume a leadership role and greater responsibility in meeting the continuing profesional educational needs of engineers as determined by this study. This recommendation can be implemented by—

(*c*) A greatly expanded educational program in all phases of computer sci- mathematics (probability and statistics, calculus, modern algebra, review of college mathematics); physics (review of college physics and solid state physics); and chemistry (review of college chemistry).

(*b*) Additional courses of instruction in the engineering sciences, especially in subject matter where high demand has been demonstrated in this study; e.g., electronics, engineering analysis, engineering economy, engineering materials, and heat transfer.

(*c*) A greatly expanded educational program in all phases of computer sciences and their scientific and engineering applications to business and industry.

(*d*) Additional courses of instruction in the subject matter of engineering analysis, design, and systems, where a high degree of need has been shown, such as automation; instrumentation, measurement, and process control; systems engineering; and program evaluation and review techniques.

(*e*) A larger program in communications specifically for practicing professional poeple with emphasis on such topics as improved reading techniques, conference leadership, technical writing, and oral presentation of statistical and technical information.

(*f*) More extensive offerings in general management, personnel management, and financial management to meet the needs of the engineer whose main responsibilities have become administrative and managerial.

(*g*) Added offerings in those social sciences and humanities which relate to the work of the practicing engineer, such as economics, logic, English composition, ethics, psychology, community relations, technology and economics, technology and human values, and humanities in a technological society.

2. Seminars, workshops, and other informal types of noncredit instruction should be increased to meet the demand for advanced education not directed to the goal of a higher degree.

3. Continuing professional education programs should be expanded and offered at convenient times and in as many locations as possible. These offerings should utilize schools, colleges, and other facilities suitable for instructional purposes and be located within commuting distances of as many engineers as possible.

4. Associate degree programs should be expanded to meet the requirements of industry for technicians in such fields as computer, instrumentation and control, and general engineering technologies.

5. New techniques of learning should be explored to facilitate the updating of practicing engineers. Suggested methods are correspondence study and in-plant courses plus periodic campus study, radio and telephone lectures, tape recordings, and educational television. A special inquiry should be made into the use of self-study and tutorial methods.

6. Engineering faculty must imbue the undergraduate with the importance of keeping abreast of new developments after graduation, and with the need for continuing self-instruction and lifetime learning.

7. Evaluation programs must be devised and conducted to demonstrate the extent to which participation in continuing education programs improves the engineer's effectiveness on his job.

For the company

1. Management, to be creative, should initiate and foster the updating of its employees. This process requires a three-pronged attack: (1) Personal motivation of the individual employee; (2) the strong support and encouragement of supervisory personnel; and (3) company policy which insists on updating its personnel as a part of the daily work.
2. More released time should be granted engineers to take advanced degrees and noncredit work. For this purpose, sabbatical leave should be provided as a regular practice.
3. Long-range educational programs should be initiated and financed to parallel long-range company programs and policies.
4. Top management should review periodically the updating needs of its practicing engineers and initiate corrective action where necessary.

For the professional society

1. Professional societies, in conjunction with universities, should seek to motivate engineers to pursue continuing professional education.
2. Engineers should be encouraged to become active in their professional societies in order to keep abreast of current technical developments as reported in the literature and professional meetings.
3. Professional societies should expand their offerings of short-term courses, utilizing, where feasible, varied media of instruction to fulfill the needs of practicing engineers.

For the State government

1. Policies of the State government should foster updating by—
   (*a*) Periodic reviews of updating needs of its practicing engineers and initiating corrective action where necessary.
   (*b*) Providing educational assistance for employees who undertake continuing professional education to keep abreast of current developments in their fields.
   (*c*) Initiating and financing long-range educational programs to parallel long-range programs and policies.
   (*d*) Granting released time to engineers to take advanced degrees and noncredit work. Sabbatical leave should be provided on a systematic basis.

For the engineer

1. The engineer has a responsibility to himself and to his company to undertake continuing professional education to keep abreast of current developments in his field.

MUSEUM OF COMPARATIVE ZOOLOGY,
HARVARD UNIVERSITY,
Cambridge, Mass., August 27, 1965.

HON. EMILIO DADDARIO,
House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN DADDARIO: I recently had an opportunity to read a statement by Dr. Alvin M. Weinberg on the future role of NSF, which was to have been presented before your subcommittee on July 8, 1965. There is a great deal of sound commonsense in this statement and I wholeheartedly agree with Dr. Weinberg's imperative: "Make the coming age the 'age of biology.'"

Dr. Weinberg speaks as a physicist and looks at certain matters from his parochial viewpoint. He seems to think that all of biology is health related and that the National Institutes of Health should and could take care of biology. He implies that most of biology ought to be transferred to NIH and that NSF become primarily, though not exclusively, an agency dealing with the support of the physical sciences.

I shall not discuss, in detail, support for the physical sciences but want to point out that most of the $1½ billion estimated to go for basic research in DOD, AEC, NASA, for 1965 will go to research in the physical sciences. To denote the National Science Foundation to the limited role of serving as an agency for the physical sciences would greatly weaken biology and achieve precisely the opposite of what Dr. Weinberg said should be achieved in future years; namely, a strengthening of biological research.

There are vast areas of biology, particularly those dealing with whole organisms and with populations that are not "health related." When Dr. Weinberg says: "I visualize NIH greatly expanding its role as a National Science Foundation for the basic biological sciences," he overlooks the fact that ultimately NIH is basically devoted to applied science. Only in this case it is applied to health problems, while in DOD physical science is applied to defense problems and in the AEC it is physical science applied to problems of atomic energy.

The precise argument which Dr. Weinberg uses, that the physical sciences "being the handmaidens of [applied] agencies * * * can hardly expand," is true for biology if entirely attached to an applied, health-related institute."

Biology is far bigger than its health-related aspects and would suffer cruelly if turned into a "handmaiden" of an agency specifically constituted to be essentially applied (health directed). I am not, in the least, questioning some of the superb basic research going on in NIH, but its scope is clearly limited. Vast areas of biology have not received any attention by NIH, and should not if NIH wants to live up to its constitution. This includes most of environmental biology, population biology, evolutionary biology, invertebrate paleontology, much of phychobiology, much of genetics, and marine biology, to mention a few areas that have just come to my mind (without any attempt at completing this list).

It is of the utmost importance that basic biological science not only remain in NSF, but that it be greatly strengthened. Biological research is far more apt to produce results which run counter to our cherished beliefs and prejudices than is physical science. To maintain the independence and dignity of biological science it is important that it continues to receive support from an independent agency, which is specifically charged to promote basic research, rather than an applied agency.

Dr. Weinberg points out correctly that many of the most "crucial public problems that are now emerging, need entirely new approaches." Although they "do not obviously fall directly in the physical sciences," he hopefully expresses the wish that physical scientists might be of use "as people well grounded in the discipline of the exact physical sciences transfer into more complex, more difficult, social sciences." This is surely true. Yet, operational research in the last war had shown surprising, that naturalists, who are used to operating with numerous unknown variables, were often superior to physical scientists in the study of complex systems. Naturalists are among the kinds of biologists who would find it difficult to get support from a purely health related agency.

To sum up, it would seem to me that nothing would weaken biology as much as a transfer of the non-health-related areas of biology from NSF to NIH.

Indeed, the very arguments which Dr. Weinberg uses in favor of strengthening the physical sciences in NSF militate even more strongly in favor of a drastic expansion of the biological sciences in the National Science Foundation.

I say with Weinberg: "Make the coming age the age of biology" by strengthening not only applied, but also basic biology. That objective, however, can be achieved properly only within the National Science Foundation, with its uncommitted interest in basic research in all branches of biology.

Sincerely yours,

ERNST MAYR,
Member, National Academy of Sciences.

UNIVERSITY OF PITTSBURGH,
DEPARTMENT OF HISTORY,
Pittsburgh, Pa., August 31, 1965.

Hon. WILLIAM MOORHEAD,
House Office Building,
Washington, D.C.

DEAR BILL: I understand that the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics is currently undertaking the first legislative review of the National Science Foundation since it was established. I have spoken to you in the past in appreciation of your efforts in behalf of a National Humanities Foundation, and am extremely pleased with the progress this effort has made. But I wanted to write you as well about the relationship of the social sciences to the National Science Foundation.

As you know, historians have many diverse interests and while some have very close ties to the humanities, others have equally strong interests in the social sciences. This is especially true of such fields as economic, political and

social history. We have, therefore, been especially interested in the development of the National Science Foundation's interest in the social sciences and have hoped that this interest would grow so that the Foundation could play as significant a role in the progress of the social sciences as it has in the natural sciences.

I understand that the current review of the National Science Foundation's activities includes its potential in this field. I know that you are not a member of the subcommittee, but I thought that because of your strong interest in the academic community you might wish to know of our interest in the social science activities of the National Science Foundation.

With best wishes,

SAMUEL P. HAYS,
Chairman, Department of History.

REED COLLEGE,
OFFICE OF THE PRESIDENT,
Portland, Oreg., September 2, 1965.

Representative EMILIO Q. DADDARIO,
Longworth Office Building,
Washington, D.C.

DEAR REPRESENTATIVE DADDARIO: During the last week of your subcommittee hearings, I corresponded with Mr. Philip Yeager regarding the suggestions of Dr. Arthur Scott for improvement in undergraduate education in the sciences, particularly chemistry. We sent a memorandum by Dr. Scott for inclusion in the record of your hearings.

Reprints of the relevant articles authored by Dr. Scott are now available. I thought you might appreciate a copy, which I have enclosed.[1]

May I also express the appreciation of all people associated with Reed College for your invitation to President Sullivan to testify before your committee. We are complimented that you provided him the opportunity to discuss his views.

Sincerely,

JOHN B. TALMADGE,
Administrative Assistant.

HOUSE OF REPRESENTATIVES,
Washington, D.C., September 3, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development, Committee on Science and Astronautics, House of Representatives, Washington, D.C.

DEAR MR. CHAIRMAN: I am enclosing a copy of the letter I have received from Samuel P. Hays, chairman, Department of History, University of Pittsburgh, Pittsburgh, Pa., regarding the National Science Foundation, which I thought would be of interest to you.

With best regards,

Sincerely,

WM. S. MOORHEAD,
Member of Congress.

UNIVERSITY OF PITTSBURGH,
DIVISION OF THE SOCIAL SCIENCES,
OFFICE OF THE DEAN,
Pittsburgh, Pa., September 3, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development,
House Committee on Science and Astronautics,
Rayburn House Office Building, Washington, D.C.

DEAR CONGRESSMAN DADDARIO: I have been reminded of the testimony that your subcommittee has been receiving on the National Science Foundation, more particularly on the social sciences.

You will be aware that the social sciences tend to be left out, at least in large part, from the terms of reference of the NSF; the situation may be the same for the proposed "National Humanities Foundation." This is most unfortu-

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[1] Articles referred to are contained in committee files.

nate. Many of the gravest and most knotty academic problems deserving Federal Government support currently must make do with low or no budgets, despite generous support for some social science themes that have come from private organizations.

It is true, of course, that many of the most important research areas in the social sciences are sensitive, and may even be considered "political." All the more reason, in an inquiring society such as ours, to encourage the rigorous application of scientific methods to their analysis and (hopefully) to their solution.

I urge you to widen the scope of NSF to include the social sciences.

My very best wishes.

Sincerely,

RICHARD L. PARK, *Dean.*

UNIVERSITY OF CHICAGO,
DEPARTMENT OF ANTHROPOLOGY,
Chicago, Ill., September 7, 1965.

Hon. EMILIO DADDARIO,
Subcommittee on Science, Research, and Development,
House of Representatives,
Washington, D.C.

DEAR MR. DADDARIO: I have just been apprised of the fine work of your committee in the general field of science and in your interest in the development of the social sciences. As you might expect, my colleagues and I are immensely interested in the work of your committee, and would be eager to receive any information from you concerning your plans, and would be happy to assist you with any advice we might be able to offer.

Wishing you every success in your important venture, I am,

Sincerely yours,

MELFORD E. SPIRO,
Professor of Anthropology.

ECONOMETRICA,[1]
September 9, 1965.

Hon. EMILIO Q. DADDARIO,
House Office Building,
Washington, D.C.

DEAR CONGRESSMAN DADDARIO: I understand that your Subcommittee on Science, Research, and Development has been conducting hearings on the work of the National Science Foundation.

As an editor of one of the economics journals dealing with some of the more technical aspects of the field, I see a large number of research reports from scholars all over the country. A number of these indicate that the work has been supported by grants from the National Science Foundation. My impression is that in this way the Foundation has been responsible for important financial assistance given to this branch of the social sciences. This is support that is very much needed, not only in economics but in the other social sciences as well, and I am writing to urge the continuation and expansion of the social science programs of the National Science Foundation, in view of the accomplishments to date.

I have also served during the past 3 years as a consultant to the National Science Foundation on its equipment grants program in the social sciences. In that capacity I have seen some very noteworthy proposals. The Foundation has been able to give some important help in these cases, though only on a limited basis because of its own limitation of funds. I believe that this program has also been demonstrably worthwhile and that the availability of more funds for it would, in terms of accomplishments, prove to be very worth while from a national point of view.

I do not wish in any way to understate the achievements of the National Science Foundation in developing the study of our social institutions. These achievements have been great, and I hope that the program will be continued and expanded because there is much paydirt that remains to be tapped.

Sincerely yours,

ROBERT H. STROTZ, *Managing Editor.*

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[1] Published at Northwestern University by the Economic Society.

UNIVERSITY OF MICHIGAN,
DEPARTMENT OF SOCIOLOGY,
Ann Arbor, Mich., September 10, 1965.

Dr. WESTON VIVIAN,
House Office Building,
Washington, D.C.

DEAR WESTON: I have been reading with great interest reports of the hearings by the Subcommittee on Science, Research, and Development. Scientists, and especially the social scientists, form only a minute part of your constituency, but I thought you might like to know that at least one social scientist is impressed by the care and foresight shown in reports of your subcommittee's work. I wanted also to reinforce what I have seen of testimony before the subcommittee, namely the thesis that wise planning does not now require the allocation of vast new funds to support social science. We need, as the testimony indicates, some additional funds to support students and facilities and selected, larger scale research undertakings. We also need to have a position within the National Academy of Science commensurate with our position in the National Institutes of Health and within HEW: a position in which we are recognized as full-fledged members and through which we can gain such financial and other support as we may come to need and merit.

Congratulations on a difficult job well done.

Sincerely,

GUY E. SWANSON.

DARTMOUTH COLLEGE,
DEPARTMENT OF ECONOMICS,
Hanover, N.H., September 29, 1965.

Hon. EMILIO Q. DADDARIO,
Chairman, Subcommittee on Science, Research, and Development,
House Office Building
Washington, D.C.

DEAR MR. DADDARIO: We have learned recently that your subcommittee is reviewing the scope of the National Science Foundation's activities and that lately the subcommittee has shown some positive interest in the relationship of the National Science Foundation to the several social sciences. We urge that your subcommittee recommend an intensification and broadening of Federal financial support of the social sciences and, especially, of the various fields of economics with either the National Science Foundation or a new and correspondingly specialized foundation for the social sciences as the instrument for administering the support. We feel strongly that the advancement of our Nation on many critical fronts is closely dependent on continuing advancements in social science research and that substantial Federal support of this research is not only justifiable but also urgently necessary.

Respectfully yours,

M. O. Clement, J. A. Menge, Robert M. Dent, Jan A. Stewart, Frederick J. Glover, Gary McDervell, Tom Elle, Gerald L. Childs, Martin L. Lindahl, Laurence Hines, Daniel Compton, Richard L. Pfister, William H. Wrean, David A. Belsky, William L. Baldwin, Harvey Galper, Colin D. Campbell, Clyde E. Dankert, Members of Department.

NATIONAL SCIENCE FOUNDATION,
NATIONAL SCIENCE BOARD,
Washington, D.C., October 4, 1965.

Hon. EMILIO Q. DADDARIO,
Rayburn House Office Building,
Washington, D.C.

DEAR MR. DADDARIO: It has been some time since several of us who are members of the National Science Board took opportunity to write to you with respect to the various questions which you raised during the summer hearings concerning the National Science Foundation.

I have given much thought to these matters in the interim, particularly with respect to the role of the Board.

My crystal ball is not clear enough to project the longtime position which should be established. I do know that the current position, de jure, is simply not practicable. The Board is responsible, in the law, not only for the generation of policy but for the operations of the Foundation. The question which has been raised is whether or not that relationship should be changed to one which is purely advisory. Much can be said on behalf of such a suggestion in which I have previously concurred. It would seem to be realistic, it would recognize that the Congress is the true board of trustees of this Foundation. and it would free the Board to serve as critic of the Foundation staff were such a position ever desirable. Let me say at once that at this moment in time, quite the contrary is the case. To my knowledge all of my colleagues share my admiration and respect to those in charge of the affairs of the Foundation, i.e., Dr. Haworth and his senior colleagues.

But I do not believe that the Nation will be well served at this moment by swinging the pendulum this violently. Certainly such an action would be taken amiss by the totality of the academic and scientific communities. And it would directly stand in contrast to the structure of the recently created National Foundation for the Arts and Humanities, which was clearly modeled after the NSF.

What is required, I do believe, is a transition to a new situation in which the Board retains its present position with respect to the determination and generation of policy for the Foundation but surrenders its authority with respect to operation. It is the latter aspect of its current responsibility which is impracticable and troublesome. Such a transition would be understood by all concerned and be entirely sensible at this time.

I am not at all certain whether such a transition requires legislation or whether we can continue, as presently we do, with the Board actually serving in the role of policymakers while delegating its authority increasingly to the Director with respect to operations. It seems to me this is the matter for your determination. It would result by either route, legislation or voluntary action on the part of the Board, in a clearly defined arrangement whereby the Board retains its present responsibility and authority with respect to the generation of policy, surrenders all authority with respect to operations and is available to the Director, as an advisory body, for consultation with respect to those operations.

I know that it is late to place such a letter in your hands, but if matters have not yet gone beyond some irreversible point, I hope that you will find it of interest and perhaps of some use to you.

Sincerely yours,

PHILIP HANDLER.

James B. Duke, Professor, Chairman, Department of Biochemistry, Duke University, Vice Chairman, National Science Board.

THE ASSISTANT SECRETARY OF COMMERCE,
Washington, D.C., October 4, 1965.

Hon. WESTON E. VIVIAN,
House of Representatives,
Washington, D.C.

DEAR MR. VIVIAN: I regret the delay in providing response to the question you raised during the National Science Foundation hearings concerning the use of Government research facilities by industry; however, we have been searching for any reports that might exist which are specifically directed to this question. To our knowledge, no such extensive report exists, nor have we been able to identify any systematic study of the use that is being made by industry of Government research facilities.

From my own background knowledge and experience on this matter, we have attempted to identify some specific examples of the relationships which exist between industry and Government. I should note, however, that where such relationships do exist, they are conducted with diversity and inconsistency. I would like to relate a few examples:

The Atomic Energy Commission has internship programs at a number of its national laboratories where it brings qualified people from industry, at AEC expense, to participate in research and carry back science and technology to the industrial laboratories. NASA has the beginnings of a similar program.

The National Institutes of Health do make their laboratories completely accessible to industrial visitors from the pharmaceutical and medical instruments industry, although there are apparently no NIH-sponsored industrial investigators. There is some question as to whether there are or are not industrial investigators participating in setting up some of the Environmental Health Centers of the Public Health Service.

The Department of the Interior has concluded at least two types of arrangements. In the Bureau of Mines there was a recent instance where a pilot plant scale blast furnace was made available to a consortium of steel companies, who were interested in exploring new methods for steelmaking and for utilization of scrap. Also, in the Bureau of Mines the Oil-Shale Experiment Station in Rifle, Colo., was made available for experimentation by commercial groups, including Union Oil Corp., to conduct tests on oil-shale recovery and refining. The Office of Saline Water operates some of the demonstration plants (Government-sponsored) with joint crews of OSW and industry personnel.

The Department of Defense has many laboratories, such as the Lincoln Laboratory, the Naval Research Laboratory, etc., where some degree of cooperation and use, jointly with industry, has been established. However, data are not on hand about the extent or conditions for industrial participation.

Within the National Bureau of Standards, industry is making use of facilities at least to the following extent: there are now 40 industrial research associates at NBS (there were 34 here at the beginning of 1965). These industry-sponsored research associates are in addition to our professional staff of 1,700.

You will find attached hereto a list of the laboratories of the Federal Government where there appears to be at least potential for joint cooperation with industry. I am also including a table showing the number of scientists and engineers employed in the Federal establishments, by agency, which provides further background on the potential use of research facilities by industrial groups.

I trust that this information will prove helpful to you, and please feel free to contact me if we can be of any further assistance.

Sincerely yours,

J. HERBERT HOLLOMON.

FEDERAL ORGANIZATIONS FOR SCIENTIFIC ACTIVITIES THAT ARE OR COULD BE USED BY INDUSTRY

DEPARTMENT OF AGRICULTURE

Agricultural Research Service

- Control and Regulatory Research.
- Agricultural Research Center.
- Other field stations and installations:
  - Eastern Utilization Research and Development Division.
  - Northern Utilization Research and Development Division.
  - Southern Utilization Research and Development Division.
  - Western Utilization Research and Development Division.

Cooperative State Experiment Station Service

Forest Service

DEPARTMENT OF COMMERCE

National Bureau of Standards

Coast and Geodetic Survey

- Office of Cartography.

Weather Bureau

Bureau of Public Roads

DEPARTMENT OF DEFENSE

Department of the Army

- Chief of Research and Development: Technical and Industrial Liaison Office.
- Medical Research and Development Command field stations and installations:
  - Walter Reed Army Institute of Research.
  - U.S. Army Prosthetics Research Laboratory.
  - U.S. Army Medical Research Laboratory.
  - U.S. Army Medical Research and Nutrition Laboratory.
  - Medical Equipment Development Laboratory.
  - U.S. Army Tropical Research Medical Laboratory.

Corps of Engineers field stations and installations:
U.S. Army Engineer Research and Development Laboratories.
U.S. Army Cold Regions Research Engineering Laboratory.
U.S. Army Engineers Geodesy, Intelligence and Mapping Research and Development Agency.
U.S. Army Waterways Experiment Station.
U.S. Army Engineer Reactors Group.
U.S. Army Polar Research and Development Center.
Chemical Corps fields stations and installations:
U.S. Army Chemical Research and Development Laboratories.
U.S. Army Chemical Corps Biological Laboratories.
U.S. Army Chemical Corps Nuclear Defense Laboratory.
Dugway Proving Ground.
Ordnance Corps field stations and installations:
Diamond Ordnance Fuze Laboratories.
Frankford Arsenal.
Watervliet Arsenal.
Aberdeen Proving Ground.
Quartermaster Corps field stations and installations: Quartermaster Research and Engineering Command.
Signal Corps field stations and installations:
U.S. Army Electronic Proving Ground.
U.S. Army Combat Surveillance Agency.
U.S. Army Signal Electronic Research Unit.
U.S. Army Signal Research and Development Agency and Laboratory.

Department of the Navy

Bureau of Naval Weapons field stations and installations:
U.S. Naval Explosive Ordnance Disposal Technical Center.
U.S. Naval Ordnance Laboratory.
U.S. Naval Weapons Laboratory.
U.S. Naval Air Test Center Aerodynamics Laboratory.
Research centers:
Applied Physics Laboratory.
Ordnance Research Laboratory.
Ordnance Aerophysics Laboratory.
Allegany Ballistics Laboratory.
Applied Physics Laboratory.
Office of Naval Research field stations and installations:
U.S. Naval Research Laboratory.
U.S. Navy Underwater Sound Reference Laboratory.
U.S. Naval Biological Laboratory.
Arctic Research Laboratory.
Bureau of Ships field stations and installations:
U.S. Navy Electronics Laboratory.
David Taylor Model Basin.
U.S. Navy Underwater Sound Laboratory.
U.S. Naval Radiological Defense Laboratory.
U.S. Naval Engineering Experiment Station.
U.S. Navy Mine Defense Laboratory.
Bureau of Yards and Docks field stations and installations: U.S. Naval Civil Engineering Laboratory.

Department of the Air Force

Air Force Systems Command field stations and installations:
U.S. Air Force Missile Test Center.
U.S. Air Force Flight Test Center.
U.S. Air Force Missile Development Center.
U.S. Air Force Special Weapons Center.
Arnold Engineering Development Center.
Air Proving Ground Center.

Office of Aerospace Research field stations and installations:
- U.S. Air Force Office of Scientific Research.
- U.S. Air Force Cambridge Research Laboratories.
- Aeronautical Research Laboratory.
- Research centers: Joint Service Program Research Centers:
  - Research Laboratory for Electronics.
  - Laboratory of Insulation Research.
  - Radiation Laboratory.
  - Microwave Research Institute.
  - Control Sciences Laboratory.
  - Cruft Laboratory.
  - Stanford Electronics Laboratory.
  - Microwave Laboratory.
  - Electronics Research Laboratory.

THE DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

Field stations and installations.

National Institutes of Health

Field stations and installations:
- National Institute of Allergy and Infectious Diseases.
- National Cancer Institute.
- National Institute of Mental Health.
- National Institute of Neurological Diseases and Blindness.
- National Heart Institute.

Bureau of State Services

Field stations and installations:
- Arctic Health Research Center.
- Robert A. Taft Sanitary Engineering Center.
- Communicable Disease Center.

Food and Drug Administration

Eighteen field stations and installations.

DEPARTMENT OF THE INTERIOR

Bureau of Mines

Field stations and installations:
- Divisions of Minerals:
  - Applied Physics Research Laboratory.
  - Minneapolis Mining Research Center.
  - Denver Mining Research Center.
  - Spokane Office of Mining Research.
  - Albany Metallurgy Research Center.
  - College Park Metallurgy Research Center.
  - Minneapolis Metallurgy Research Center.
  - Reno Metallurgy Research Center.
  - Rollo Metallurgy Research Center.
  - Salt Lake City Metallurgy Research Center.
  - Tuscaloosa Metallurgy Research Center.
- Division of Anthracite: Anthracite Research Center.
- Division of Bituminous Coal:
  - Morgantown Coal Research Center.
  - Pittsburgh Coal Research Center.
  - Coal Mining Research Center.
  - Explosives Research Laboratory.
  - Denver Coal Research Laboratory.
  - Grand Forks Lignite Research Laboratory.
  - Seattle Coal Research Laboratory.
- Division of Petroleum:
  - Morgantown Petroleum Research Laboratory.
  - Bartlesville Petroleum Research Center.
  - Laramie Petroleum Research Center.
  - San Francisco Petroleum Research Laboratory.
- Assistant Director for Helium: Helium Research Center.
- Assistant Director for Health and Safety: Health and Safety Research and Testing Center.

Office of Saline Water
Scientific activities: Division of Demonstration Plants.

POST OFFICE DEPARTMENT

Office of Research and Engineering
Scientific activities: Postal laboratory.

DEPARTMENT OF THE TREASURY

Field stations and installations.

Internal Revenue Service
Thirteen field stations and installations.

ATOMIC ENERGY COMMISSION

Field stations and installations:
Laboratory facilities operated directly by the agency.
New Brunswick Laboratory and Health and Safety Laboratories.
Division of Biology and Medicine:
Scientific extramural training: Assistant Director for Administration:
Atomic Energy Commission special fellowships in health physics, industrial hygiene, and industrial medicine.
Visiting biologists program.
Traveling science teachers program.
Mobile isotope training unit.
Contractor-operated research and training facilities:
Idaho Operations Office: National Reactor Testing Station.
New York Operations Office:
Cambridge electron accelerator.
Princeton-Pennsylvania proton accelerator.
Princeton stellerator.
Savannah River Operations Office: Savannah River Laboratory.
Oak Ridge Operations Office:
Oak Ridge National Laboratory.
Oak Ridge Institute of Nuclear Studies.
Puerto Rico Nuclear Center.
University of Tennessee Agricultural Research Laboratory.
Chicago Operations Office:
Ames Laboratory.
Argonne National Laboratory.
Albuquerque Operations Office:
Los Alamos Scientific Laboratory.
Mound Laboratory.
Sandia Laboratory.
San Francisco Operations Office:
Lawrence Radiation Laboratory, Livermore Branch.
Lawrence Radiation Laboratory, Berkeley Branch.
University of California at Los Angeles, atomic energy project.
University of California Medical Center, Radiological Laboratory.
Brookhaven Office: Brookhaven National Laboratory.
Schenectady Naval Reactors Office: Knolls Atomic Power Laboratory.
Pittsburgh Naval Reactors Office: Bettis Atomic Power Laboratory.

FEDERAL AVIATION AGENCY

Aviation Research and Development Service: Field stations and installations: National Aviation Facilities Experimental Center.

FEDERAL COMMUNICATIONS COMMISSION

Two field stations and installations.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Field stations and installations:
- George C. Marshall Space Flight Center.
- Michoud Ordnance Plant.
- Ames Research Center.
- Lewis Research Center.
- Flight Research Center.
- Goddard Space Flight Center.
- Goddard Institute for Space Studies.
- Jet Propulsion Laboratory.
- Wallops Station.
- Langley Research Center.
- Manned Spacecraft Center.
- Western Operations Office.

SMITHSONIAN INSTITUTION

Field stations and installations.
- River basin surveys.
- Tracking stations.

TENNESSEE VALLEY AUTHORITY

Field stations and installations.

TABLE I.—*Scientists and engineers engaged in research and development, by agencies* [1]

Agencies	*Total*
Department of Defense, total	24,598
Office of the Secretary of Defense	69
Department of the Army	8,332
Department of the Navy	11,320
Department of the Air Force	4,877
Department of Health, Education, and Welfare	3,804
Department of the Interior	3,871
Department of Agriculture	5,067
Department of Commerce	2,176
Department of Labor	185
Department of State	25
Federal Aviation Agency	463
Atomic Energy Commission	534
National Aeronautics and Space Administration	8,571
Tennessee Valley Authority	182
Other [2]	569
Total	50,045

[1] Extracted in part from "Scientific and Technical Manpower Resources," Publication No. NSF 64-28, published by the National Science Foundation; ch. III, p. 67, table III-65.
[2] Includes the remaining agencies of the executive branch, except the [Veterans' Administration] Central Intelligence Agency and National Security Agency; also includes the small numbers of scientific and engineering personnel employed by agencies of the legislative and judicial branches.

ASSOCIATION OF STATE COLLEGES AND UNIVERSITIES,
October 8, 1965.

Hon. GEORGE P. MILLER,
Chairman, Committee on Science and Astronautics,
House of Representatives,
Washington, D.C.

DEAR CONGRESSMAN MILLER: President Fred Harcleroad of the California State College at Hayward has informed me of your interest in "ASCU Studies No. 4-1965" which contains the report of the ASCU Committee on Federal Grants. We hope this information can be brought to the attention of the committee.

You are most welcome to use or reproduce any of the material contained in this report in any way you see fit.

We would appreciate having a copy of the committee report when it is available. Please let me know how we might be of further service to you.

Sincerely,

ALLAN W. OSTAR,
Executive Director.

REPORT OF COMMITTEE ON FEDERAL GRANTS [1]

(From ASCU STUDIES NO. 4, 1965)

(By John R. Emens, president, Ball State University, Muncie, Ind.)

There has been much discussion and some collection of facts concerning the participation in Federal programs by colleges and universities which are members of the Association of State Colleges & Universities. Some grants have been available to institutions of higher education for many years, but during the past few years programs and expenditures have expanded. It is increasingly difficult to keep well informed and to develop the knowledge necessary to obtain the grants desired. Your committee composed of President John King (Emporia, Kans.) and myself is endeavoring to highlight these programs by presenting here a résumé of the study conducted by Dr. David Rice, director of institutional research at Ball State University, in 1964. The more significant data are presented in a chart and table as an appendix to this report.

This study covered selected programs in the National Science Foundation and in the Office of Education. It was restricted to proposals submitted for approval during the fiscal year 1963. It was similar to an earlier study of proposals submitted in fiscal year 1962. The 1962 study brought responses from 142 members; 24 did not report. In 1963 there were 175 members. Of these, 129 responded; 46 did not.

In 1962, 58 of the institutions responding did not request participation in any of the programs surveyed. Among the 84 institutions which submitted proposals, 62 (73.8 percent) had 1 or more approved.

In 1963, 41 of the 175 respondents did not submit requests. Among the 134 which did 71 institutions (80 percent) had 1 or more proposals approved.

We selected the National Science Foundation and the Office of Education for study, believeing that their types of grants were more related to our kinds of programs. In the National Science Foundation we listed sponsored research, course content improvement, institutes of science and mathematics, undergraduate instructional equipment, and undergraduate science education. We have maintained in all of our contacts with NSF, whenever we have visited them, that we believe it is essential to improve instruction in the elementary and secondary schools through these programs, as well as in some instances to conduct research. We believe also that even in research in most instances the Congress wanted many projects related to elementary and secondary schools as well as to collegiate education. In our type of institution, in which such a large percentage of people are involved in learning how to be teachers, at the inservice or graduate level, we should expect some real consideration.

Our study of grants requested in 1963 shows that we have been recognized in some areas. In others we owe it to our selves to get our institutions busy if they really want to do a teacher education job with some help from the Federal Government.

In the entire United States in 1963 there were 5,356 requests for sharing in sponsored research. Of these, 2,709 were approved—an approval rate of approximately 50 percent. There were 87 proposals from our ASCU institutions, and 40 were granted. This means we had a 46 percent approval rate. The number of ASCU proposals was 1.6 percent of the total submitted. Our percentage approval of the total volume was 1.5 percent. The amount we received was 0.8 percent—eight-tenths of 1 percent—of the total funds appropriated. The reason for the 0.8 percent is that although ASCU members received 1.5 percent

[1] This report summarizes and analyzes the more significant findings of a study conducted in 1964 by Dr. David Rice, director of institutional research, Ball State University, Muncie, Ind. President Emens has pointed out important implications for ASCU members and has suggested next steps. The data collected by Dr. Rice were reported in detail in "ASCU Studies No. 3, 1964."

of all grants made, many of the grants we obtained were smaller than the average.

In the field of course content improvement, there were 233 requests in the whole United States, and 99 of them were approved—42 percent of the total. I do not know whether it is shocking, but it is surprising that of 177 institutions of our kind only 5 of us were sufficiently interested in course content improvement to ask the Federal Government to assist us. We obtained one grant, or 20 percent; the ASCU percentage of proposals was 2 percent of the total; approvals, 1 percent.

For science and mathematics institutes there were altogether 1,404 proposals with 929 approvals—an approval rate of 66 percent. Our institutions asked for 127 of the total 1,404. We had 82 approvals or 664 percent; 9 percent of the total number of proposals and 6.8 percent of the total number of dollars appropriated for that purpose.

For help in obtaining undergraduate instructional equipment, there were 829 requests and 523 approvals. We had only 47 institutions that "needed" (enough to request) this equipment; 66 percent of those who asked were granted some money; 4.5 percent of the dollars were allocated to ASCU institutions.

For undergraduate science education,there were 1,095 requests and 596 approved, or 54 percent approval. We submitted 23 different requests and 13 were granted, or a 56 percent approval rate; and, again, 1 percent of the money.

Of the total of those 8,917 requests submitted to NSF there were 4,856 approvals, which is a 54-percent rate. There were 289 requests from all of our institutions put together, with 167 approvals, which is an approval rate of 58 percent of those who asked. But this is only 3.5 percent of the total number of approvals because approximately 50 percent of our people did not ask.

We turn now to the Office of Education programs, and again I say the ones studied were selected; they were not the total group. In the cooperative research programs there were 600 requests altogether and 148 grants—a 24.7-percent rate. We had 31 who asked and 11 were approved or a 35 percent approval rate. You notice this is better than the national rate for this group. The grants to our members totaled 3.8 percent of the dollars.

The study showed 124 requests for National Defense Education Act guidance institutes and 76 granted. Eight of our institutions asked for these institutes and only three were approved. Our proposals were 6.9 percent of the total; of these, the ones approved represented 4 percent of the grants and 1.9 percent of the dollars.

In the program of National Defense Education Act language institutes for elementary and secondary schoolteachers there were 156 requests submitted and 83 approvals, or a 53 percent rate. We had 12 institutions that asked and 8 grants, which means we were way up in terms of the total number granted and requests made. We received 10 percent of the dollars.

The totals for these Office of Education programs were 880 requests and 307 approved, or a 35-percent approval rate; for ASCU there were 22 approvals for a 43-percent approval rate.

I do not know how significant this is, but remember there were 9,902 requests made and 5,163 grants approved; 53 percent of them were approved. We sent 340 requests and there were 189 approvals, or a 56-percent rate.

These are the programs we need to talk about. Among the new areas are the National Defense Education Act institutes, expanding into at least seven additional fields. These include the Division of Handicapped Children and Youth. Also, there is the Elementary and Secondary Act of 1965, which is supposed to appropriate again large sums of money for the improvement of elementary and secondary education. This should be of major interest to us.

These are the kinds of things we need to follow up. The concern of the committee was how we should proceed for the future. We have some facts; we have some information. We know that half of our institutions either have had a bad experience or do not have the know-how or are not interested. What should we do about these institutions? Is there some way our association can help institutions which want to have more know-how, more skill, more competence; institutions that want to find ways to participate in more of these programs and enhance their opportunities for service?

We suggest first that we might have conferences or institutes. There are two or three ways. One would be to hold regional conferences in various places on a volunteer basis.

Second, it has been suggested that we send individuals from our institutions to Washington and that Walter Hager and the group there might arrange for us to meet with different people. But I think that before we take this step it is necessary for each institution to have somebody on the campus who is going to coordinate these activities. If they just float around here and there, they get lost in the shuffle. There are various ways to accomplish this task. We at Ball State University started out in the very beginning, as I have told you, by asking a member of our faculty, which happened to be Dr. Rice, if he would devote the same amount of time to this as if he were teaching an extension class. It soon worked up to full time, and now we have employed another individual for next year. He is one of the faculty who has been in Washington working on these grants, and he is coming back to be assistant director of institutional research.

We suggest that you need such a person in your institution, and we suggest that he be from the faculty group. This individual needs to work with every faculty member. On our campus Dr. Rice works with each faculty member in any department which wants to prepare a request. He is expected to keep available for these people all types of information that comes out of Washington on the different kinds of programs, the laws and the restrictions within them, definitions, and suggestions about how you get the know-how.

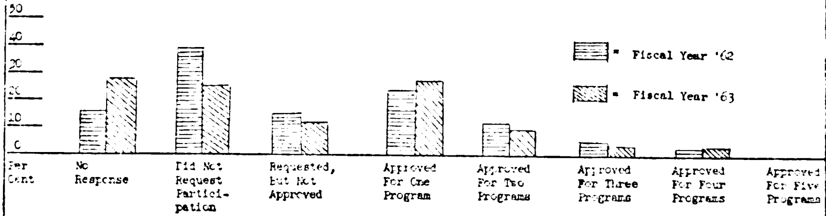
You need to get a certain amount of know-how centered in one person. This person should be able to assist any faculty member in developing a program or a request. You need someone to coordinate the total program so that you will have within your institution a complete list of all requests that are somewhere between your campus and Washington or on the way back.

This brief report of your committee culminates by suggesting that:

1. Each institution in our association, if it wishes to participate in Federal grant programs, needs to have someone on the campus to coordinate the "request program."
2. ASCU might and perhaps should arrange study conferences on this subject; either regionally or in Washington.
3. We all work cooperatively with governmental agencies, foundations, and our colleagues to the end that we perform better and finer educational services.

Appendix to Report on Federal Grants

PARTICIPATION BY MEMBERS OF THE ASSOCIATION OF STATE COLLEGES AND UNIVERSITIES IN SELECTED FEDERAL PROGRAMS



	No Response	Did Not Request Participation	Requested, But Not Approved	Approved For One Program	Approved For Two Programs	Approved For Three Programs	Approved For Four Programs	Approved For Five Programs
FY '62								
No. of Institutions Responding (N=166)	24	58	22	35	17	6	4	
Per cent	14.5	34.9	13.3	21.1	10.2	3.6	2.4	
				62 or 37.3%				
FY '63								
No. of Institutions Responding (N=175)	46	41	17	43	15	6	6	1
Per cent	26.3	23.4	9.7	24.6	8.6	3.4	3.4	.6
				71 or 40.6%				

Analysis of ASCU members reporting participation in selected Federal programs in fiscal year 1963 [1]

Program	Program data		ASCU proposals	ASCU approvals	ASCU approval rate	ASCU percent of proposals	ASCU percent of approvals	ASCU percent of funds
	Total approvals	Approval rate						
NATIONAL SCIENCE FOUNDATION		*Percent*			*Percent*	*Percent*	*Percent*	*Percent*
Sponsored research	2,709	50.5	87	40	46.0	1.6	1.5	0.8
Course content improvement	99	42.5	5	1	20.0	2.0	1.0	.1
Institutes (Science-Mathematics)	929	66.1	127	82	64.5	9.0	9.0	6.8
Undergraduate instructional equipment	523	63.2	47	31	66.0	5.0	5.9	4.5
Undergraduate science education	596	54.5	23	13	56.6	2.1	2.2	1.0
Total of above NSF programs	4,856	54.5	289	167	57.8	3.2	3.5	--------
OFFICE OF EDUCATION								
Cooperative Research	148	24.7	31	11	35.5	5.2	7.4	3.8
NDEA Guidance Institute	76	61.4	8	3	37.5	6.9	4.0	1.9
NDEA Language Institutes for Elementary and Secondary Teachers	83	53.3	12	8	66.7	7.7	9.6	10.1
Total of above OE programs	307	34.9	51	22	43.0	5.8	7.2	--------
Total, NSF and OE	5,163	52.8	340	189	55.7	3.47	3.66	--------

[1] Data taken from "ASCU Studies No. 3, 1964: Grants, Salaries, Enrollment, Centralized Control," Washington, D.C.: The Association, 1964, 20 pp.

APPENDIX 8

Representation Abroad by Atomic Energy Commission

U.S. Atomic Energy Commission,
Washington, D.C., November 16, 1965.

Dr. Edward Wenk, Jr.,
Chief, Science Policy Research Division, The Library of Congress, Washington, D.C.

Dear Dr. Wenk: In response to your letter of October 8, 1965, to Mr. John J. Burke, Office of Congressional Relations, there is attached a report providing information concerning the staffing of our foreign offices. We hope the information provided will be of benefit to you. Please let us know should additional or more detailed information be required.

As evidenced in this report, we have been able to fill our principal representative positions, as they become vacant, with well-qualified personnel from within the AEC or AEC contractor organizations. Because of the specialized nature of these overseas assignments, in their relation to the administration of U.S. Government offices and programs, incumbents must possess a well-rounded background of experience in the operating and/or coordinating phases of the U.S. atomic energy programs. Such a background is difficult to obtain to an acceptable degree through involvement in the atomic energy work of nonassociated private industry or the academic community. With few exceptions, technical personnel who have completed tours of duty abroad have been absorbed into AEC or AEC contractor organizations to the considerable benefit of the Government.

We would welcome an opportunity to discuss this matter further and should you wish to do so please feel free to contact Mr. Thomas O. Jones, Assistant Director for Administration, Division of International Affairs (phone: code 119, extension 4357).

Sincerely yours,

John A. Hall,
Assistant General Manager for International Activities.

Attachments:

A. Report, "AEC Foreign Office Operations."

B. "Arrangement Between the Department of State and the AEC for Stationing AEC Representatives Abroad."

Enclosure A

AEC Foreign Office Operations

1. Function of the offices

The Atomic Energy Commission established small overseas offices, attached or associated with U.S. Embassies, in order to facilitate close and continuing liaison with foreign atomic energy programs and to assist in carrying out the Commission's program of international cooperation, including the distribution of source, special, and byproduct nuclear materials, and the exchange of classified and unclassified information. All of the offices have the above general functions to some degree. Some may have a more specialized program than others depending on the sophistication of the foreign atomic energy programs with which associated.

2. Location of present offices, dates of establishment

Currently, the Atomic Energy Commission has six foreign offices located and established as follows:

Location:	Date of establishment
Chalk River, Ontario, Canada	November 1955.[1]
Paris, France	November 1956.
London, England	December 1956.
Buenos Aires, Argentina	November 1957.
Tokyo, Japan	Do.
Brussels, Belgium	November 1958.

[1] During World War II the Army's Corps of Engineers established a group at Chalk River, Ontario, to provide liaison with the Canadian atomic energy establishment. That office continued functioning after the war and at the time of the establishment of the Division of International Affairs in 1955 the Chalk River group was transferred to the new division.

At present, one employee of the Chalk River office is located at Pinawa, Manitoba, where he provides technical liaison and coordination principally with the Whiteshell Nuclear Research Establishment of Atomic Energy of Canada, Ltd.

3. Relation to State Department officials abroad

The Atomic Energy Commission's foreign offices were established pursuant to the "Arrangement Between the Department of State and the Atomic Energy Commission for Stationing Atomic Energy Commission Representatives Abroad" (enclosure B). In discharging the functions of their respective offices, the principal AEC representatives maintain close liaison with U.S. Ambassadors, other officials of the Department of State, and other Government agencies abroad to assure mutual coordination of activities. The AEC recognizes that the authority and responsibility of the Diplomatic Mission Chief is applicable to the relationships between the AEC representatives and the pertinent Ambassadors and their staffs.

4. Standards for selection of principal AEC representatives

Due to the varying degrees of complexity surrounding the responsibilities of the various principal AEC representative positions and in consideration of the degree of advancement of the atomic energy programs with which the representative will be associated, the standards for selecting personnel to fill the vacant principal representative positions may vary. Candidates for vacancies are considered with due regard to the demands of the job in each case. Selections are made by the Director, Division of International Affairs, with the approval of the General Manager and the Commission, based on the academic and professional experience of the candidates; their knowledge of U.S. and foreign atomic energy programs; and their linguistic ability. Knowledge of U.S. Government administrative and legislative operations and demonstrated diplomacy in handling contacts rank high as desirable qualifications.

Demonstrated ability and experience within the U.S. atomic energy program, of course, are considered prime requisites for these principal representative positions. The individual selected for a principal representative position must possess sufficient scientific and technical experience, as might be gained through employment with the USAEC or AEC contractor organizations, to permit his adequately fulfilling the technical requisites of the position. He may play an important role in the development of the atomic energy programs in the countries to which assigned. Accordingly, he must have a sound background to render meaningful advice and assistance to foreign programs. The head of each foreign office must also possess sufficient administrative experience and known ability to supervise the sometimes complex operations of a U.S. Government office in a foreign country.

Diplomacy is important since the individual will represent the United States in the atomic energy field and will deal directly with various levels of representatives of the governments and atomic energy programs of the countries to which accredited. Through these contacts they can do much to enhance U.S. prestige and to maintain a U.S. influence in the atomic energy programs.

5. Personnel policies relating to these overseas assignments

Recruiting for all vacant positions overseas is accomplished in accordance with the general personnel policy of the Atomic Energy Commission and in conformance with the specific policies, practices, and procedures as contained in AEC Manual chapters 4108, "Employment" and 4141, "Foreign and Territorial Employment."

It should be noted that all sources which are likely to yield candidates with required skills are utilized in filling vacancies. Examples of possible sources are: (*a*) employees of the AEC; (*b*) AEC contractors; (*c*) AEC consultants; (*d*) other Government agencies; (*e*) professional, technical, and scientific societies and organizations; (*f*) industrial organizations, and (*g*) colleges and universities. Since inception of the AEC's foreign office program a total of 22 principal representative vacancies have been filled. Of these, 18 were recruited from within the AEC; 2 from AEC contractor organizations; and 2 from other Government agencies. None were recruited from private industry or academic institutions not associated with the Government's atomic energy program.

6. Advantages to the AEC from assignment of its own staff rather than hire scientists from the academic community for a tour of duty

Due to the nature of the programmatic and administrative responsibilities of the principal AEC representatives abroad, it is important that each incumbent have a sufficient background of experience in the programs of the USAEC. This background can only be achieved through direct participation, particularly in the technical phases of such programs over a period of years. To this time we have filled vacancies from within the AEC and AEC contractor family. The advantages of recruitment from within the program are as follows: Candidates—

(*a*) Are technically trained both formally and on the job;

(*b*) Have extensive experience in the atomic energy field;

(*c*) Have familiarity with the typical Government operation; i.e., regulations, procedures, methods of operation, etc.;

(*d*) Have proven their leadership qualifications;

(*e*) Have demonstrated an acceptable level of diplomacy and tact in their personal relations;

(*f*) Have broad knowledge through experience of personnel in the Atomic Energy Commission and in its contractor organizations, as well as in the scientific community at home and abroad, who possess special administrative and technical abilities and who may be called upon as a need arises to provide expert advice and assistance;

(*g*) Currently possess or have possessed AEC "Q" clearance; and

(*h*) Can normally be made available for assignment on a convenient schedule.

7. Disadvantages, if any

There are few, if any, disadvantages to filling principal representative position vacancies from within the program. The reservoir of qualified technical personnel within the atomic energy program appears sufficient in relation to the relatively few principal representative position vacancies occurring. Prior to March 1965, tours of duty abroad were for 2-year periods, but now are generally for a period of 3 years. In most instances, principal representatives agree to an extension or a full second tour. Thus, vacancies in the top level positions have occurred at each post on an average of every 28 months.

8. Subsequent AEC employment of scientists and engineers returning from assignments to AEC overseas offices

It is AEC policy to provide continued employment within the agency, following a tour of duty abroad, to the extent that circumstances permit such continued employment. Employees are given intensive and appropriate consideration for placement in positions and at locations which are agreeable to the employee and, of course, most beneficial to the AEC.

Since inception of the AEC's foreign office program 16 persons who occupied principal representative positions have returned from duty abroad. Of these, only four left AEC service upon returning from their foreign assignments. All of the others have returned to responsible positions within the AEC headquarters.

ENCLOSURE B

ARRANGEMENT BETWEEN THE DEPARTMENT OF STATE AND THE ATOMIC ENERGY COMMISSION FOR STATIONING AEC REPRESENTATIVES ABROAD

1. *General.*—Under the provisions of the Atomic Energy Act of 1954 (Public Law 703, 83d Cong.) provision is made for various types of cooperation with foreign countries and for agreements with foreign counties concerning such cooperation. The Atomic Energy Commission (AEC) is engaged in an increasing

volume of activity in the field of cooperation with other governments. Approximately 36 countries have now signed agreements for cooperation with the United States, and agreements with additional countries are being negotiated.

The level of this activity now makes it appear that the Commission may need to station AEC representatives abroad in a few countries to assist it in connection with these cooperative activities. The purpose of this paper is to set forth the arrangements between the Department of State and the Commission in connection with such assignments.

2. *Duties of AEC representatives.*—The duties of the AEC representatives will be determined by AEC within the field of its functions and responsibilities. They will relate primarily to operations under the agreements for peaceful uses and would be predominantly technical in the atomic energy field. The AEC representatives will maintain contact with the atomic energy establishments of the countries to which accredited and will report on the technical aspects of atomic energy developments.

3. *Relationship of AEC representatives to the Ambassador.*—The AEC representative will work in full cooperation with the diplomatic mission chief and his staff and with the International Cooperation Administration missions or personnel where present. AEC recognizes that the authority and responsibility of the diplomatic mission chief as set forth in part II of Executive Order 10575 will be applicable to these relationships. The AEC representative will be available to assist the diplomatic mission in carrying out its diplomatic and reporting functions related to atomic energy, although State recognizes that AEC normally has first claim on his time and will undertake not to make unreasonable demands upon the time of the AEC representative.

4. *Negotiations with foreign governments.*—The Atomic Energy Commission recognizes the responsibility of the Department of State and the U.S. chief of diplomatic mission for conducting all negotiations with foreign governments and will instruct its representative to work in full cooperation with the mission chief and the diplomatic staff and to follow instructions of the mission chief with respect to any negotiations. At the same time, the State Department recognizes the responsibilities of AEC for cooperation with other governments in the atomic field and will instruct the chiefs of diplomatic mission to assist the AEC representatives in the development of those contacts with foreign officials which are necessary and reasonable in the execution of their duties for AEC.

5. *Further development of atomic energy functions overseas.*—It is recognized that atomic matters will be of growing importance in the conduct of foreign relations in the future and that the activities carried out overseas by the Atomic Energy Commission may also increase. The Department of State may find it necessary to assign to some posts full-time Department officers for political and economic problems related to atomic energy. AEC may find it necessary to increase its staff of representatives as the foreign activities for which it is responsible increase. The International Cooperation Administration also has certain responsibilities in the atomic energy field which will require attention by ICA field staff in the U.S. operations missions. In this developing situation, it is agreed that there should be continuing consultation between ICA, State, and AEC to assure that there is full understanding and cooperation in the fields of mutual interest, such as the reporting of foreign development, and to assure full and effective use of staff available abroad for functions related to atomic energy.

6. *Selection of AEC representatives.*—AEC representatives will be selected, paid, and assigned abroad by the Atomic Energy Commission. However, prior to making a commitment to assign an officer to a particular post, AEC will obtain the concurrence of the Department of State.

7. *Communications.*—State Department communications facilities will be used by the Atomic Energy Commission and its representatives. Chiefs of U.S. diplomatic missions and AEC representatives shall be expected to comply fully with the provisions of sections 201(b)(5) and 203(b) of Executive Order 10575 concerning communications.

8. *Administrative services.*—The State Department will provide to the AEC representatives office space, equipment, facilities, and administrative services in accordance with the approved policies and procedures of the State Department concerning administrative services for other departments and agencies and reimbursement for such services.

INDEX OF PERSONAL NAMES

51-204—65—vol. II——42

SUBJECT INDEX

A

B

C

D

E

F

G

H

I

J

O

V

W